The Integration of Subjects Enhances Learning

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Abstract

The integration of subjects/domains in the classroom is key to student engagement and to developing the critical thinking skills which allow children to make connections and globalize thinking. Neuroscience has given new insight into how the amygdala and the reticular activating system (RAS) filter data, providing understanding to why integration works. In order for the brain to process information globally and make connections, relevancy and context are critical. When students learn subjects departmentally without real world applications, the brain often fails to make connections to other subjects or situations and causes students to become disengaged from the learning. Integrating social studies with math, literacy and science skills and concepts through Culturally Responsive Teaching (CRT) practices enables students to develop understanding and appreciation for their world, while still teaching math and literacy skills and science concepts; the main focus of today's education. This research explored the validity and value of integrating subjects. The results showed that the integration of two or more subjects did increase engagement and generate deeper understanding.

Keywords: brain, Culturally Responsive Teaching (CRT), elementary school, integration, math, reticular activating system (RAS), science, social studies, student engagement.

Introduction

Social studies (history, geography, economics and political knowledge) are critical knowledge for students in order to become contributing members of society. However, due to the push for accountability, many schools have set aside social studies for math, reading, and writing. This does not make sense. Why not bring social studies into those classes? Social studies tie information to culture, bringing context to other subjects and developing a greater understanding of each subject and domain. Integrating subjects builds stronger connections in the brain and allows students to apply knowledge and skills globally.

It is important that we as educators understand how the brain intakes, analyzes and synthesizes data. Neuroscience has shown that students process information in relation to prior knowledge and learning. At the same time, learning develops through social constructs. Therefore, lessons should be developed that tie new information to prior knowledge and include social interaction. Integration of subject matter presents new information while engaging students in a socially interactive way, strengthening connections across subjects and domains.

The engagement of students is critical to learning. Carol Dweck (2006) explains that students often come to the classroom with a fixed mindset about certain subjects. When a student sees himself/herself as "bad" at math, then it is difficult for that student to engage. However, when math is taught in conjunction with a subject that the student likes, the student is more likely to engage in learning math, supporting further the efficacy of integrating subjects.

This paper consists of two parts: the literature review and a case study. The literature review, entitled *Integrating Social Studies into Science and Math in Order to Make Content More Meaningful and Relevant*, which starts on page 5, explains the importance of Sand why integration is a better format for constructing information. The mixed methods case study, *A*

Case for Integration: Integrated Units of Study Make Learning More Effective, starts on page 20. The study follows a small group of fifth graders through a ten-day integrated unit. The results show that integration does promote engagement and leads students to making global connections.

Integrating Social Studies into Science and Math in Order to Make Content More Meaningful and Relevant

Colorado's Department of Education (CDE) recognizes the importance of social studies in the development of students as responsible citizens. In the state standards for social studies, attention is on key elements, which lead students to become productive members of society. In addition, the study of history, geography and economics build interpretive, analytical, and critical thinking skills as well as an understanding of personal responsibility. Social studies also teach students to evaluate choices and make rational decisions. The crossover of these skills and abilities into other disciplines and subject content help students to generalize and make more pathways in the brain. National Geographic and their supporters, such as Daniel Edelson confirm CDE's belief. Edelson (2014) asserts the need for students to understand how simple decisions affect the larger community.

Not everyone in our nation understands the importance of social studies. An editorial posted in *City Journal* (Beran, 2012) states that social studies has "out lived its usefulness" and claims Social studies is brain washing students to become completely compliant to a socialist society. Beran proclaimed social studies is used to further political agendas and stifles individualism and capitalism. This common misconception has been reinforced by the United States educational systems' lack of conviction and improper employment of teaching methods; such as reading straight from text books and memorization of dates and names. Social studies are very important because it provides: a foundation for citizenship, an understanding of governments and basic geography, and foundational knowledge required to become a productive member of society (Colorado Department of Education, 2009; Edelson, 2014; National Geographic, 2015). Social studies instruction fills the gaps in cultural differences between home and school (Herrera, 2010; Schocker, Croft, Licwinko, Muthersbaugh, Rosetti, & Yeager, 2012).

Children must know and understand their own culture and history before they can appreciate the similarities and differences of other cultures (McIntosh, 1990). Children must be able to read and understand maps and globes before they can connect to other places. Children must have a basic understanding of supply and demand, so they can grasp how these forces effect themselves and the world's economy. When children lack basic geographic and economic skills and knowledge, content gaps are generated that must be filled before new information can be added (Guidry, Cuthrell, O'Connor, & Good, 2010; Hinde, 2005). Therefore, laying a social studies foundation in elementary school is critical. This paper explains the importance of using literature to integrate social studies into other disciplines such as science or math allowing content to be more relevant and meaningful; resulting in a student's ability to gain knowledge and skills that last a lifetime.

Reasons for Marginalization of Social Studies

Many teachers feel inadequate when it comes to teaching social studies; often their own experiences in social studies education were unpleasant. Past lessons consisted of memorization and regurgitation of dates and events and glossed over explanations of culture, differences, and different types of government. Personal connections to the material/content were never made; winding up with misunderstanding and disdain for the subject. As students themselves, many educators learned the material just to pass the unit test and then promptly forgot what they had learned. In one study, educators noted textbooks failed to engage them as learners (Crawford & Zygouris-Coe, 2008). Due to the lack of relevancy during their own instruction (Herrera, 2010), many teachers do not value social studies, misunderstand its purpose, or do not recognize influential instructional approaches (Boyle-Blaise et al., 2008).

Another key reason social studies instruction is marginalized is the lack of professional development in social studies content and instructional methods. One goal of continued

professional development in social studies is to develop teacher empathy that bridges cultural gaps and promotes equality and social justice. This can only be accomplished through relevancy and critical thinking that includes diverse perspectives (Santua & Ritter, 2013). Teachers need to be made aware of new methods and techniques in order to accomplish this daunting task. In a study conducted by Santau and Ritter (2013) fifteen elementary teachers (both novice and veteran) from western Pennsylvania were surveyed and participated in a semi-structured interview. The purpose of the study was to look at how elementary teachers view inquiry-based and interdisciplinary teaching practices in social studies and science. The results found that these fifteen teachers did not understand value based social studies, but did understand that active and integrative techniques need to be used. However, data showed only 4 of the 15 teachers (2 novices, 2 veterans—one of which was National Board Certified) were differentiating instruction to make it meaningful to students. Six of the teachers (3 novices and 3 veterans—one of which was National Board Certified) challenged students to analyze and problem solve during social studies instruction. Only eight (4 novices and 4 veterans—two of which were National Board Certified) were exploring social studies through integration of content areas. Santua & Ritter's (2013) study highlights a serious need for professional development training for elementary educators.

Since the implementation of the No Child Left Behind Act of 2002 (NCLB), accountability for language arts and mathematics has become the focus of education across our nation; causing social studies and science to take a backseat (Dorn, Douglass, Ekiss, Trapido-Lurie, Comeaux, Mings, Eden, Davis, Hinde, & Ramakrishna, 2005; McCall, 2006; Heafner & Fitchett, 2012). The Center for Education (2008) released a study which reported a nationwide average decrease in social studies instructional time of 32% (an average reduction of 76 minutes

per week) in order to increase math and language arts instructional time. The high-stakes testing that accompanied NCLB has profoundly impacted what subjects take priority, creating road blocks for subjects other than math and reading (Boyle-Blaise, 2008; Center for Education, 2008; Guidry et al., 2010; Olwell & Raphael, 2006; Passe, 2006). Efforts to increase test scores have triggered administrators to focus instruction on math and reading, the tested subjects, leaving the rest behind and untested. Several studies found schools have diminished or eliminated social studies content from their curriculum. Many children at the K-5 level are receiving less than one hour of social studies each week (Boyle-Blaise et al., 2008; Guidry et al. 2010; Jones, & Thomas, 2006; McCall, Janssen, & Riederer, 2008; O'Connor, Heafner, & Groce, 2007; Schocker et al., 2012). Another difficulty, which arose in the 1990s, was an emphasis placed on science, technology, engineering and math (STEM) (Woodruff, 2013). STEM pushes educators to spend more instructional time on these subjects, further reducing social studies instructional time (Hinde, 2005). Integration of social studies, math and science in elementary school would strengthen skills in literacy, math and science without taking precious time away from tested subjects. Integrating disciplines provides students with a social studies foundation helping them to become aware of inequalities and injustices with an end benefit of becoming productive members of society.

Making Social Studies Relevant

Teachers can create relevancy through a process called culturally responsive teaching (CRT) (Herrera, 2010). CRT is a philosophy of teaching that respects every student for who they are and what assets they bring to the classroom. CRT is a continuing process that acknowledges individuals as important members of the classroom culture and responds to them with empathy and understanding. A teacher who approaches learning through a CRT lens looks at how

learning is seen through an individual student's perspectives (Herrera, 2010; Howard, 2007). Herrera (2010) explains how intentional collection and proper use of data to determine who students are, where they come from, and their values will make teaching more meaningful to students. By collecting biographical data, including age, grade, proficiency in reading and writing skills, native language, learning styles and preferences, mindsets, self-efficacy, and background knowledge, teachers can better comprehend how to engage students in relevant and meaningful ways. The more data gathered, the more complete the understanding of whom the individual student is and what the child brings to the classroom. Once abilities, interests, and values are analyzed, lessons plans and strategies can be implemented that will help students grow both socially and academically.

Effective social studies instruction helps students develop critical thinking skills. Social studies require students to compare, contrast and critically analyze events, behavior, cultural expectations, values and beliefs. Comprehending the history of different societies and how values affect choices helps students develop understanding and empathy for others. Hinde (2005) tells us the primary purpose of social studies is education for citizenship. When students are thoughtfully taught to be productive members of their communities, strong community bonds form, creating unity and harmony.

CRT teaching methods positively affect how vital social studies concepts such as history, geography, and economics are taught. Creating a deep social studies understanding means including every perspective. For example, slavery affected all people and cultures, not just whites and African-Americans, slavery has been around for thousands of years. It is important to view slavery from different cultural perspectives and different time periods. This means

educators need true depth in their knowledge of social studies in order to teach students how to see other perspectives and gain appreciation for other people, other places, and other times.

Brain research and Integration of Educational Disciplines

Brain research has revealed how information travels inside the brain (Pawlak, Magarinos, Melchor, McEwen, & Strickland, 2003; Posner, 2010; Sousa, 2010; Willis, 2010). Sensory inputs (auditory, gustatory, olfactory, visual and tactile stimuli) are first processed in the amygdala (Figure 1) (Willis, 2010). The amygdala is the entryway into the brain; thought processes here are unconscious and automatic. The amygdala functions as a filter, which decides whether an input is antagonistic or not. If the input appears threatening (i.e. uncomfortable, stressful, or dangerous) the reticular activating system (RAS) in the amygdala sends the input to the lower, involuntary, reactive part of the brain (Pawlak, et al., 2003; Willis, 2010) placing the child in a defensive mode which interferes with learning (Immordino-Yang & Faeth, 2010). Any input that is not processed as antagonistic is sent through filters to the frontal lobe where executive functions (thinking and learning) take place (Immordino-Yang & Faeth, 2010; Willis, 2010).

Once sensory data arrives in the frontal lobe it is processed through more filters (Willis, 2010) which encode the data into patterns. Patterning in the brain refers to the process of building neuronal pathways. Neuronal pathways create meaningful organization and categorization of information on previous patterns which the brain stores in specific regions. For instance, visual information is stored in the occipital lobes (back of brain) and kinesthetic information is stored in the parietal lobes (top of the brain) (Figure 1) (Willis, 2010).

The neuronal pathways that connect the frontal lobe to the storage areas form road ways for learning. When new stimuli are examined by the frontal lobe, similarities to previously

established road ways are sought and the information is sent down a trail until a junction is formed. The recognition of similarities triggers the release of dopamine. Dopamine is one of many neurotransmitters that transport information across gaps (synapses) between the branches (dendrites and axons) of connecting neurons (Willis, 2010). When students are curious and engaged dopamine levels increase. Every time dopamine is released, it creates pathways in the brain, which increases focus, builds memory (Willis, 2010) and develops positive emotional ties to learning (Immordino-Yang & Faeth, 2010). Whenever students experience progress towards goals, connections to past experiences, or find a solution to a math problem, additional dopamine is released making the road easier to travel.

One way to think about this process is to think about roads. The first travelers into uncharted territory had to find ways around impassable mountains and the best places to ford rivers. Travel was extremely difficult. The return trip was easier because terrain was known and dangerous areas flagged. As the trail became a path, travel became easier. The path became a road which was eventually paved. Paved roads allow for quick travel. The occasional pothole might slow one down or cause the driver to swerve, but the going is still easy. When children learn new information, they go through a similar process. Travelling back and forth over the same neuronal pathways paves new roads which in turn allows new trails to be formed.

Using strategies that relate new information with memory enables students to detect patterns and make connections (Herrera, 2010; Willis, 2010). Brainstorming sessions help students connect the topic to previous learning or past experiences. Engaging classroom discussions cement learning, pique curiosity, and open new avenues for further inquiry allowing students to own their learning (Immordino-Yang & Faeth, 2010; Marzano, 2007). Journals and other forms of writing also strengthen neuronal pathways (Brock, Goatley, Raphael, Trost-

Shahata, & Weber, 2014). Willis (2010) suggests that a good way to stimulate learning is through cross curricular connections. Brock and associates (2014) encourage study across disciplines to get students thinking conceptually from different perspectives (mathematically, scientifically, and historically). Examining what students have learned about a topic from the perspective of another class or subject is another way to develop new neuronal pathways (Brock et al., 2014; Willis, 2010). Research shows that written words trigger in the left half of the brain whereas symbols, such as Arabic numerals, fire synapses in both hemispheres (Posner, 2010). Intentionally combining words and symbols into lessons allows students to use the entire brain, which increases the opportunities for learning to become concrete. Another key consideration for integrating disciplines comes from the research of Immordino-Yang & Faeth (2010). Immordino-Yang & Faeth stress the importance of including emotion into learning; simply providing factual knowledge fails to stimulate curiosity or learning. The integration of cognitive skills and emotion into a social context is the most effective and efficient way to learn.

The work of Jean Piaget (1964) has become the basis for human reasoning theories. Piaget categorized a child's learning process into four stages of cognitive development: sensorimotor, pre-operational, concrete operational, and formal operational (noting certain ages when these stages happen). However new research suggests that these stages continue throughout life. No matter how old we are, when unique stimuli (no connection to past experiences or previous patterning) are received, the brain begins a new sensorimotor stage and creates distinctive patterns for this stimuli. The next time new information presents itself that matches this distinctive pattern, the pre-operational stage commences. The concrete operational stage occurs when new skills are gained and refined supporting these new pathways. Finally, the brain moves into the formal operational stage and those skills are applied to various situations.

Piaget (1964) believed knowledge is in a state of equilibrium as long as it is not challenged. He saw how new stimuli (RAS) evoked challenges to perception that created disequilibrium. This disequilibrium forces the brain to make sense of the stimuli or discard it, which in turn results in learning. Processing and categorization occur in the frontal lobe, and data is then transferred to long-term memory, returning equilibrium. Information Processing theory (IP) builds on Piaget's work. IP explores how people identify, transform, store and retrieve data (Snowman & McCown, 2015). IP (Figure 1) theory is based on the assumption that data is processed in steps, there are limits to the amount of data that can be managed during each step, and data processing is interactive. IP believes environmental stimuli triggered by sight, sound, touch, taste, and smell are brought into sense receptors which in turn record the information in the sensory register (SR) for 1 to 3 seconds. The brain holds data just long enough to select recognizable patterns and determine if they should be attended to further or ignored and deleted (Marcovitch, Boseovski, Knapp, Kane, 2010; Willis, 2010). If data is deemed worthy of attention it will be sent to working (short term) memory. Unique information that stimulates curiosity is transferred to working memory (Willis, 2010). When lessons include novel and intriguing information, students' attention is captured. However, if this brief attention is not capitalized upon quickly, the moment can be lost and short term memory might dump the data. Instructor's recognition of the next step toward student advancement and meaningful avenues to whole brain stimulation is vital.

Capitalizing on students' engagement requires connecting working memory to long-term memory through recall of past experiences and knowledge. Working memory is critical because it encodes, organizes and retrieves data from long-term memory (Rose, Meyerson, Roediger, & Hale, 2010; Snowman & McCown, 2015). Data that reaches working memory is processed

through one or two types of rehearsal. Maintenance rehearsal simply keeps information in working memory for a specific purpose such a remembering your boyfriend's phone number until you can write it down. Elaboration rehearsal relates new information to prior knowledge and experiences; adding details and clarifying meaning to previous data (patterning). During the elaboration rehearsal processes, concrete themes or stories help to connect information making it relevant and meaningful. However, students need several strategies to transfer information to long-term memory (Sadoski, Goetz & Rodriguez, 2000; Snowman & McCown, 2015). Strategies that help the transfer of data to long-term memory include: summarizing information verbally or in writing, constructing visual images, making inferences, or creating analogies. Methods which include both verbal and nonverbal elements increase the probability of information being stored in long-term memory (Sadoski, Goetz & Rodriguez, 2000).

Integration of Social Studies with Math and/or Science

Literacy (Brock et al. 2014; Moss, 2005) and concreteness of subject content (Sadoski, Goetz & Rodriguez 2000) are key for tying disciplines together (Brock et al, 2014; Moss, 2005). Two methods for integrating social studies, math, science and reading are through literature and thematic units. Educators need to change their perception of content area literacy and understand how rich literacy education can become when taught through the integration of social studies, science and math. The CDE provides instructional strategies in their Literacy Design Toolkit which provide additional information about using literacy to increase disciplinary skills (http://www.cde.state.co.us/cosocialstudies/instructionalstrategies). This toolkit provides educators with online training and support to build literacy skills across content areas. Use of the Literacy Design Toolkit can help bridge the social studies content gap and increase math and science skills.

Using literacy skills to integrate is important, however creating relevancy is critical. Every new unit/lesson/topic should begin with a questioning period that intentionally seeks to uncover students' background knowledge of the topic. Research has found that it is critical to the successful outcome of a lesson to establish what students know, what they want to know and then clearly state learning objectives (KWL) (Brock et al. 2014; Herrera, 2010; Marzano, 2007). Taking time to understand each student's background knowledge is key to setting objectives. Delving into background knowledge is more than just knowing previous academic knowledge. Herrera (2010) describes background knowledge as having three parts. First is a student's funds of knowledge which comes from the child's family; traditions, native language, home literacy practices, and family dynamics. Next is prior knowledge; understanding what a child has gained through his/her community and social interactions. The last consideration is academic knowledge; what the child remembers from previous formal educational experiences. In order to obtain this information, questions should always be open-ended and specific. Student comments and/or general ideas should be written and posted in a highly visible place that can be easily referenced throughout the lesson.

The KWL session informs lesson direction by providing the foundational setting on which to build. One example of integrating math and social studies was clearly illustrated by Kinniburgh and Byrd (2008). Using two children's books, *Ten Black Dots* (Crews, 1968) and *September 11, 2001: Attack on New York City* (Hampton, 2003), a lesson integrating math and social studies was presented to fifth graders. Kinniburgh and Byrd (2008) asked students to discuss what they knew about the events of September 11th and recorded comments on chart paper. The introduction of Hampton's (2003) book was read; giving a clear synopsis of that day's events. Discussion was reopened to find out what knowledge had been gained. New

information was recorded on chart paper and hung next to the first chart for comparison. The original comments were ambiguous and generalized, whereas comments after the lesson were emotional, specific and detailed; showing deeper levels of thinking (Table 1).

Moving into the math lesson, objectives and reasoning behind the transition from social studies to math were clearly spelled out. Students were given an explanation of how Crew's (1968) book uses dots to represent things in the world around us. The purpose was to show how geometry connects to the world; focusing especially on congruence and similarity. After reading the book out loud, the students were asked to think about how dots could be tied into the events of September 11th. Kinniburgh and Byrd (2008) gave the students 10 black self-sticking dots and asked the children to make a picture using the dots. At the bottom of the paper, students wrote an explanation, using both the written word and the Arabic symbol for the number of dots used, about the significance of their picture. One student wrote how dots represented windows on the first tower hit by the plane. Another used eight black dots to represent the eyes of four crying children who lost their parents in the attack. The pictures and writing conveyed feelings and deep understanding of the events of September 11th as well as geometry and congruency.

Kinniburgh and Byrd's (2008) use of children's literature was effective because the stories and pictures promoted engagement. Children's literature and historical fiction bring characters and places to life triggering students' involvement and curiosity. Introducing historical content in ways that engage children also creates a disequilibrium in the cognitive processes. Disequilibrium causes a strong desire to return to equilibrium, so that balance between background knowledge and content is restored (Piaget, 1964). Well planned lessons will develop critical understanding of social issues and comprehensive understanding of the material itself.

Through connections with the historical figures and depictions, meaningful connections will be made by the reader; bridging the time gap and helping to create relevancy.

Another way to develop relevancy is through intentional, well planned thematic units. A study conducted in Arizona (Dorn et al., 2005) sought to discover the efficacy of integrating math and geography (GeoMath). Developmentally appropriate thematic units were created by a group of 28 teacher-authors working in conjunction with a university. The study included 3,008 students, kindergarten through eighth grade, from 113 classrooms across the state plus a control group that mirrored the demographic data of the study group. The study group was taught a lesson that integrated geography and math, whereas the control group was taught each subject separately. All students were given a math pre-test and a post-test was given one month after the lesson in order to determine retention of new material. The study discovered teaching math in context with geography fostered significant improvement in mathematical skills. Using a pair-wise t-test, the researchers revealed the control group showed little to no improvement, however the study group showed a statistical significance at $p < 0.001$. To assess the efficacy of the geography lesson, a mix of performance-based and selected response assessments were used (score of 80% considered mastery). Social studies outcomes were self-reported by classroom teachers. Results showed 54 of the 113 classrooms had students who reached mastery in the geography content. Dorn and associates (2005) were impressed enough by the results of this study, as well as the preliminary analysis data from another study being conducted jointly by Arizona and Michigan geographic alliances, that they recommended expanding the GeoMath program as long as growth is tested and monitored for refinement of lesson planning.

Thematic units also appear on the CDE website as resources for teachers. A unit designed for fourth grade titled “Boom and Bust” presents opportunity for integrating literacy, math and

science into social studies content (Figure 2). CDE math standards 1.1 (understanding decimals), 1.2 (fractions), 1.3 (formulating and using algorithms) and 3.1 (data analysis with visual displays) naturally fall into an investigation into the fur trade economy. CDE science standards 2.1 (similarities/differences among organisms) and 2.3 (interaction/interdependence among living things) evoke inquiry as to why and how the fur trade affected ecosystems. Reading historical fiction and researching for actual data will teach students about how one person's decision to become a fur trader can be tied into modern day decisions that will affect future generations. Intentionality in planning theme based units on student responses to key questions will develop understanding of math, science, and social studies while increasing literacy skills.

Conclusion

Effective integrated instruction retains the integrity of the subject matter through a deeper understanding of different perspectives. This deeper level of integration helps students to transfer critical thinking skills into other disciplines. Students will be able to think like scientists, mathematicians and historians (Moss, 2005). It is essential that educators build a foundation of social studies concepts and content knowledge in elementary school students to foster good citizenship skills. Professional development must be provided which will enable the integration of social studies throughout the curriculum in meaningful and relevant ways. Through proper and intentional use of interdisciplinary studies, social studies can be integrated with math and science through literary art skills. Using children's literature, historical fiction, and thematic units, students can learn new strategies that will become second nature. The inclusion of multiple types of text rather than text books will enhance literacy skills and rouse curiosity (Moss, 2005). Jones and Thomas (2006) echo the need to incorporate cross-disciplinary skills and proclaim it is vital for underserved content areas like social studies. Children can learn to think like mathematicians,

scientists and historians by developing critical thinking skills, analyzing texts and synthesizing data across all the disciplines. Through intentionality and with specific objectives, the integration of social studies, science, and math content can become relevant and meaningful to students.

Positive change will only come if people recognize the importance and value social studies brings to our lives every day. Social understanding cannot change if students do not understand and respect cultural differences. In order to understand governmental processes, students need to know how and when those ideals and principles were developed. George Santayana (*The Life of Reason*, 1906) wrote, "Those who cannot remember the past are condemned to repeat it." The opposite of this statement is even more profound – Those who learn from the past, can and will make the future a better place.

Further study of the efficacy of integration will be researched through the development of an integrated social studies, math and/or science lesson for upper elementary school students using age appropriate historical fiction. Learning goals will be based on CDE standards. CRT teaching practices will be used to determine learning preferences and styles as well as background information. The lesson will start with a KWL session. Charts showing students' previous academic knowledge and progression will be posted in a visible, easily accessible location throughout the learning process and added to as needed. After new learning material is presented, class discussions and/or pair-share discussions will help students to process the new content. Journaling and other strategies, such as the summarization of information verbally, making inferences, constructing visual images, and creating analogies will be used to strengthen neuronal pathways. Assessment of academic learning will come from pre- and post-tests in each discipline taught as well as work samples and student comments.

A Case for Integration:

Integrated Units of Study Make Learning More Effective

As adults, we encounter all subjects and domains on a daily basis, whether or not we realize it. Math isn't regulated to an hour a day. Rather, math permeates our society; the speed we drive to get from place to place and the distance it takes to stop our car relies on mathematical concepts. Reading is not just sitting down to a good book. We must read the signs on the road to know where to go, the labels on food to decide if it is a healthy choice, and to make informed decisions. The departmentalization of subjects is causing a disconnect in our children's brains. When math, reading, writing, social studies, and science are taught in isolation, the brain does not automatically develop the neural pathways that allow a person to make connections across domains (Devlin, 2010; Fischer & Heikkinen, 2010). The brain needs to develop those connections through experience and socialization. Learning must be contextualized in order for the brain to make meaning of the information and then to apply that information to a new situation (Fischer & Heikkinen, 2010; Vygotsky,1978). For students to develop the ability to think across domains and to make global connections requires educators to develop integrated curriculum that supports crossing domains and subjects. This is especially important during childhood (Hohnen & Murphy, 2016). Educators should focus on how each subject applies to a topic or theme and how that topic/theme connects to students' cultural knowledge and experiences, community, home and school (Eun, 2010; Herrera, 2010; Morcom, 2014; Vygotsky, 1978). Eun (2010) asserts the need for contextualized learning based on students' background knowledge and abilities. Intentional and purposeful integration of subjects increases the likelihood that children will make connections to their world in meaningful ways.

The focus of this paper is to examine how integrated instruction engages all students, makes learning more meaningful and helps students make global connections. This study seeks to answer the following questions: How important is students cultural and academic background knowledge in integrated instruction? Does integration of two or more subjects into a thematic unit increase engagement and generate deeper understanding? Will the integration of subjects provide students with a greater ability to make global connections? How does an integrated unit affect a student's mindset? Why does social interaction increase learning?

Literature Review

Neuroscience research has provided new insights into the inner workings of the brain (Ansari, 2010; Devlin, 2010; Hohnen & Murphy, 2016). Research reveals that sensory information enters the brain through the amygdala, which determines whether or not the situation is safe. If the amygdala determines the information is safe, then learning can begin (Hohnen & Murphy, 2016; Willis, 2010). From the amygdala, sensory information then moves into the hippocampus, where spatial relations and connections are made. Next, neural pathways send the sensory data to the frontal lobe where the information is translated into patterns then organized and categorized (Willis, 2010). Scientists have determined exposure to stimulating experiences, such as integrated units, make stronger connections between the different areas of the brain, producing better cognition and enhancing long-term memories (Sale, Berardi & Maffei, 2014; Hohnen & Murphy, 2016). As students age, it is important to expose them to interdisciplinary materials, which will increase the connectivity between the regions of the brain facilitating higher order thinking skills (Rees, Booth & Jones, 2016).

The ability of the brain to change (neural plasticity) depends on previous activity along established pathways in order to fortify and augment learning (Rees, Booth & Jones, 2016).

Difficulties arise when unique information, not fitting a known pattern or category is encountered, as often happens with rote learning. Consequently, new information must be tied to previous learning in order for students to comprehend, analyze, and synthesize the new material (Herrera, 2010). Providing experiences that activate multiple areas of the brain simultaneously helps strengthen pathways making cognition stress free, which in turn facilitates learning (Hohnen & Murphy, 2016). The more activity there is, the stronger the connections will be, leading to efficacy of both knowledge and skill (Sale, Berardi & Maffei, 2014; Hohnen & Murphy, 2016).

While it is true that rote learning should play a role in education, it must be accompanied by comprehension gained through experience in order for the learning to become pertinent and produce useful skills (Devlin, 2010). Comprehension relies heavily on making connections to past knowledge, both academic and cultural (Herrera, 2010; Clark & Flores, 2014). Unlike the precise storage and retrieval of a computer, the human brain recognizes patterns and works by association (Devlin, 2010). That is not to say that a child should never be introduced to novel ideas and experiences (Willis, 2010). However, springing new information or unfamiliar experiences on students without previous knowledge can be stressful and interfere with the learning process (Herrera, 2010; Immordino-Yang & Faeth, 2010; Pawlak, Magarinos, Melchor, McEwen, & Strickland, 2003; Willis, 2010). Teachers must bridge the gap between old and new information in order to help students engage in the learning experience (Herrera, 2010; Willis 2010).

Cross-curricular connections stimulate learning (Willis, 2010). Often, students consider themselves to be “good” or “bad” at a certain subject. Students who feel good about a subject or skill will readily engage in the learning. However, a student with a negative fixed mindset about

a particular subject will balk whenever the subject is broached (Dweck, 2006). By using a purposefully integrated topic, students can be exposed to each of the domains/subjects in a less threatening manner. Integration provides the means to engage students more readily and for them to make connections more easily. Furthermore, having students examine their learning of a topic from numerous perspectives (mathematically, scientifically, and historically) allows the brain's plasticity to create new pathways, in turn enhancing higher-level thinking (Brock et al., 2014; Willis, 2010).

Further research has also proven that bringing math and science symbols into a unit strengthens existing connections and creates new neural pathways. Written words are only processed in the left hemisphere of the brain, whereas symbols, such as icons and Arabic numerals, stimulate pathways in both hemispheres. When this type of integration is executed with purpose and intentionality, conceptual learning becomes more concrete (Posner, 2010).

Another key factor in integrated learning is the social/emotional component (Immordino-Yang & Faeth, 2010; Vygotsky, 1978). Research reveals that learning, motivation, and emotions are interdependent (Dweck, 2016; Eun, 2010; Herrera, 2010; Morcom, 2014; Vygotsky, 1978). Children cannot properly learn without feeling safe and secure in their environment; relationships with both adults and peers need to be respectful, productive and stress free in order to promote learning (Maslow, 1943; Immordino-Yang & Faeth, 2010; Hohnen & Murphy, 2016). It is through social interactions, context and properly planned experiences that student learning is supported and encouraged (Eun, 2010; Herrera, 2010; Morcom, 2013; Vygotsky, 1978).

When planning integrated units of study, social interactions must be intentional and use students' interests, learning styles, and background knowledge for grouping (Herrera, 2010). Large and small group work, as well as time for individual work, are critical to engagement and

learning so students can build off one another's knowledge. Herrera (2010) referred to Krashen's (1984/2002) Input Hypothesis (i+1), which explains the need for students to be exposed to information just beyond their current level of mastery. The i+1 correlates to Vygotsky's (1978) Zone of Proximal Development (ZPD); both explain that every student has attained a certain level of cognition, but needs to be provided with external stimuli and scaffolding in order to reach the next stage. In addition, Hohnen & Murphy (2016) stress the importance of being able to think with freedom, rather than engaging in competition, so that one's thoughts can be more dynamic. Lieberman (2012) explains people naturally crave social interaction and when that interaction is non-existent or stifled, students' minds will wander, inhibiting learning. However, when instruction contains relevant, real, and intentionally interdisciplinary material students are engaged, they retain key facts, and they formulate global connections (Herrera, 2010; Lieberman, 2012; Taylor & Parsons, 2011).

In order to properly integrate, an educator must have strong positive relationships with students. Integration should take into consideration students' strengths, preferences, and areas for growth as well as cultural and academic background knowledge in order to avoid misunderstandings that could hinder the learning process. Integration will be successful if contextualized instruction supports a connection between the real-life experiences and school, using both sensory and social experiences that build upon students' background knowledge (Eun, 2010; Herrera, 2010).

Integrated learning helps students to make global connections by tying things they already know to the unique and unusual. Integration helps them to think past the math or the science and into what-ifs of the world.

Methods

Participants

The participants of this study were seven fifth graders ages 10 and 11 who were opted out of PARCC testing because their parents did not see the value of standardized testing and two students, age 10, who were in alternative testing.

Alan, an only child with autism, is on an Individual Education Plan (IEP). He reported that both math and science were completely interesting and completely useful. Then he noted that he did not like history because it is not "useful." In the regular classroom, Alan only stays on task if the task is challenging and useful. He often states, "That's too easy, I'm not gonna do it." Unfortunately, Alan was only present on days one and two.

Buffy is an average student with a great work ethic who is academically slightly below her fifth grade peers and meets with a tutor two days a week. She is organized and diligent. She missed days six and seven due to illness, but asked her mother to pick up research materials for her so she could work at home. Buffy wrote that math is her favorite subject because she uses it every day. She also noted at the beginning of the unit that science is useful, but it was not her favorite subject, further stating, "it can sometime be a little boring." However, by the end of the unit, she wrote that she now likes science and enjoyed learning new things.

Carl is a quiet, socially awkward eleven-year-old boy who scores proficient at the fifth grade level and is apathetic about grades. Carl consistently says, "Why do grades matter? Grades don't matter!" He wrote that he is interested in math because it will help him in the future, but it is not his favorite subject. Science, on the other hand is very interesting to Carl. He likes the hands-on experiences that are part of the science curriculum.

Delany is a ten-year-old girl who puts her social life before her academic life. She is an average student, scored barely proficient by her teachers. She expresses an interest in math "because it is fun and exciting" and "lets me think." On the other hand, she believes science to be uninteresting and only slightly useful. There was no change in Delany's impression of science possibly because she was only present for days eight and nine.

Katie's teachers describe her as a student with great potential who refuses to do anything about it. She scored proficient in all her classes without much effort. Like Delany, Katie is a very social child. She reported that she dislikes math, but realizes that it is useful. Alternately, she wrote that she is completely interested in science and finds it very useful. Katie was only present on day six because she had just transferred to our school and the paperwork was not in the system, yet.

Rachel suffers from seizures and is challenged with delayed cognitive development. She is on an IEP. She talks with a robotic voice and reads with little prosody. Her academic test scores place her at a second grade level in reading comprehension and math skills. Rachel reported that she has an interest in math and that math is very useful. She is very interested in science and finds it completely useful. When asked a question, Rachel usually answers and then restates the question. However, the answer does not always reflect the truth. For instance, Rachel is from the Middle East, but when asked where her family comes from she replied in her robotic voice, "I do not know." Then when asked if she was from India, she replied, "Yes, I am from India." Although comprehension is a problem for Rachel, she expresses a sincere desire to learn new things and puts a lot of effort into trying to understand.

Sherlock is in the gifted and talented program in both math and reading. He consistently asks profound questions and delves deep into research. He scores above average in all subjects,

but declared “grades aren’t everything.” He stated that math is interesting because it is related to everything a person does and it helps you to learn other subjects faster. But, science is his favorite subject “because science helps us to discover, clarify and unravel mysteries.”

Of the seven students, only two had any sense of their family’s heritage. Delany talked about Celtic dancing and her participation in events such as the Long’s Peak Celtic Festival, but her knowledge of her heritage stopped there. Sherlock noted that his dad is from France. Carl asked what it meant and then said, “I’m American.” The lack of an identifying heritage was very evident in all seven students. Other than attending the same grade in the same school, there were few commonalities in cultural traditions. Rachel, Buffy and Sherlock shared a strong work effort and belief that if they worked hard enough, they could master anything. Alternatively, the other four had fixed mindsets, believing they did not have the potential to excel. Moreover, Alan, Carl, Delany and Katie only put in enough effort to meet the requirements, while Buffy and Sherlock continued to increase their skills and knowledge when they had met the requirements.

Instruments

A math and science interest survey (Appendix A) was filled out both at the beginning and the end of the unit. Student biography information was gathered through informal interviews. A KWL (Appendix B) was filled out by each student independently before starting the unit. Each student was given a notebook in which to record notes, draw pictures and record data. At the end of each day, questions based on the day’s discussions and topics were asked in order to formatively assess student learning. Biography cards (Herrera, 2010) (Appendix C) were filled out for five of the seven students in order to determine background information, cultural affiliations and values and previous academic knowledge. On the last day, a summative test (Appendix D) was administered.

Using a scale of 1 to 5, where 1 was disengaged and 5 was completely engaged; data was collected each hour of the class and then averaged for each day (Table A).

Procedures

This mixed methods study was conducted over a three-week period with seven fifth grade students who had either been opted out of PARCC testing or who were in alternative testing. There were four sessions of one and one-half hours and six two-hour sessions. Notes were taken hourly on student engagement.

Intervention

The curriculum for this unit was chosen in order to capture the students interest and expose them to several domains of learning at the same time in an intentionally integrated unit. Content included math (mean, mode, median, and range), science (composition of the planets, gravity, atmospheric conditions, other bodies in the solar system), social studies (how, why, and when planets were discovered and named) and language arts (research, written report, and presentation of findings). A 5E lesson plan was developed for the entire unit. Each day began with a short story, discussion or video in order to engage the students. Books of appropriate reading levels were provided. Computers and Think Pads were made available for each student. Expectations were given verbally and written on the white board. Students were given direct instruction for new skills and procedures in short 5- to 10-minute blocks, with the rest of their time spent in either individual work or in students-led group discussions.

Day one was spent building background knowledge about the planets. The students were given a worksheet that guided their research. The option of working independently or in pairs was also given. The majority of the time was spent in individual research; however, spontaneous discussions ensued each time a student discovered new and exciting information.

On day two, a math lesson was taught. Thirty minutes was the planned time for the lesson and worksheets; however, the students requested more time to explore the math. They continued working for a full hour, searching out real world examples for their new math skills. The rest of the time was spent on researching planet data. The girls worked together and the boys individually on the math portion. All research was done independently. However, teacher support was provided for the students with special needs.

Day three began with the video, "Pluto, et. al: 'What is a Planet' 2007 NARACHEL; IAU Definition of a Planet" (Jeffry Quitney, https://www.youtube.com/watch?v=N5YrKZUymjQ). After the video, a discussion was held about what they thought the definition of a planet should be. Students were asked to write their definition in their space notebooks. Upon completion of their answer, the students were directed to an interactive lesson titled "Jupiter is Average" on the Beacon Learning Center website (http://www.beaconlearningcenter.com/WebLessons/JupiterIsAverage/default.htm).

After a couple of minutes exploring the website, the students realized that the word "average" must have context. They questioned what the context should be and came to individual decisions about what their context would be. Using the planet information previously gathered, one chose the diameter of the planets, another chose to look at the revolution of the planets, and two chose to look at atmospheric conditions.

The survey (Appendix A) showed all students showed an interest in math. In order to build on that interest, day four started with the video "What Happens at the Edge of the Universe? Space/Time Measuring the Size of the Universe" (PBS Digital Studios). As the video was being set up, Buffy requested more practice with mean, mode, median, and range. While the students were watching, an additional worksheet was prepared for those who wanted it. The rest

of day three and all of day four were spent in independent research, with the teacher/researcher facilitating as needed.

Gravity was introduced on day six. The lesson began with a KWL followed by a video on gravity. The students were directed to include how gravity affects their chosen topic. For the next two days, students conducted research and put together a presentation. Then on day nine, two of the students presented their findings to the rest of the group.

On the last day, class started with a test. Presentations were to be completed after the test. However, the students really took their time on the test, and we were not able to get to the presentations; instead the students turned in their presentation materials along with a written report.

Results

Testing data from the end of the unit was compared with the KWL sheets filled out on day one. The KWL data showed that six of the seven students knew little or nothing about the planets or how to calculate mean, mode, median, and range. All four students who participated from beginning to end, showed a marked increase in their knowledge, with an increase in test scores of 30% to 70% (Figure 1). On average test scores increased 52.5 %.

One student, Sherlock, knew the order of the planets and their basic compositions. He also knew the origins of the planets names, along with the myth associated with each name. All the students understood that gravity is the force that keeps them on the ground, however only Sherlock had more than a basic understanding of gravitational force.

Test scores at the end of the unit showed Buffy had mastered mean, median, and range. She also had a better knowledge of the physical features of three of the outer planets, as well as an in-depth knowledge of asteroids and the asteroid belt that lies between Jupiter and Mars.

Carl had increased his knowledge from a few basic facts (eight planets, one dwarf planet, the order of the planets, and "gravity is what keeps us on the ground") to understanding that planets are made out of rocks and gas, how to figure out the mode, and the formations of galaxies, especially the Milky Way. His KWL score was 0% whereas his final test score was 70%.

Overall, students started with low engagement scores; however, those scores jumped up quickly and maintained an average level of 4 throughout the study (Table A, Figure 2). One anomaly in engagement was that Rachel's level of participation dropped before gradually climbing to a peak of 4.5. Another variance presented itself over the last three days. Carl's engagement dropped on day eight and again on day nine, ending the unit at a level 3 (participating but often off topic).

Discussion

This purpose of this study was to explore if an intentionally, purposefully student-centered and integrated unit will create an environment that not only motivates student learning, but actively engages students in order to develop deeper meaning and create greater connections across domains, which students can then apply globally.

As the unit started, engagement (Figure 2) averaged 2.3, which means that most of the students were participating reluctantly. Trepidation was in their eyes, with one exception. Sherlock quickly showed his excitement with his discussions of why the planets were named after Roman gods. When Carl complained, "I thought this was about science, not history" Sherlock led a discussion about how history and science are connected. The discussion lasted about 15 minutes, and by the time it ended Carl begrudgingly acknowledged his understanding of the interconnection between social studies and science. It was through these spontaneous,

student-initiated discussions that individuals were able to make meaningful connections between daily life and the different subjects being explored.

On day two, math was purposefully introduced into the unit in order to build on student interests (Appendix E). As soon as the lesson started, students began to ask questions and to make important connections between the math, the science, and their lives, furthering the belief that learning becomes more relevant and meaningful when multiple domains are integrated. As a result of their higher interest in math, four of the five students took charge of their own learning, even asking for more practice problems and examples, which in turn led to better retention and understanding for everyone except Rachel. Due to a cognitive gap, Rachel, who is on an IEP with diagnosed developmental delays, struggled with the concepts of mean, mode, median, and range. Her absence of background knowledge and deficit in comprehension likely caused her lack of engagement.

Day eight presented another challenge for engagement. Carl's level of engagement dropped. Carl is a middle-of-the-road student who completes the bare minimum in order to keep the teacher off his back. It was on this day that Carl had completed his assignment. Having met his obligations, he expressed no desire to continue researching or to start on a new topic. The other students were engrossed in their own projects, so Carl moved away to the edge of the classroom and resisted every attempt to re-engage him. With the idea that he had accomplished what was asked of him and with no social interaction, he disengaged from the rest of the class.

Every student who participated for more than two days showed a huge growth in their knowledge of outer space and the planets. Comparing the final test scores with the initial KWL showed huge gains in knowledge and skills for the four children who completed the unit.

However, this was not the only growth shown. Each student showed improvement in all the domains: history, math, social studies, research, and science. In research, the students were able to identify reliable resources and comb through information to find data, which bolstered their knowledge of their chosen topic. In math, the students were able to calculate mean and identify mode. They talked in detail about how history and science affect our daily lives. The connections that were made were also taken a step further by applying them to other aspects of daily life, as well as concerns for the future.

Observations throughout the unit showed that social interaction has a direct positive correlation to engagement and learning (Vygotsky, 1978). As the students talked and built off of each other's learning, engagement increased. Depth of knowledge increased, as well. For example, when Rachel asked for further clarification about how to figure out the average of a set of numbers, Buffy offered to help. Consequently, Buffy was forced to restate and reword the process several times before Rachel finally understood. This restating and rewording for the benefit of the other student, allowed Buffy to become more confident in her knowledge and reinforce her learning. Sherlock and Carl had a similar experience when Sherlock tried to explain how gravity keeps comets in a specific orbit. This back-and-forth exchange gave each student more ownership of their learning and provided the added benefit of repetition, which improves pathways in the brain.

The effectiveness of these discussions can be attributed directly to the peer-to-peer explanations, student background knowledge, and shared cultural mores. The added benefit of having a higher-level student in the class became very apparent on day five (Figure 1, Figure 2). The students were comparing and contrasting comets and asteroids. The conversation moved to what types of interplanetary bodies hit the earth. The researcher/teacher tried to explain, but it

was Sherlock who was finally able to put it in a reference that the other students understood, thus leading to group engagement and greater depth of knowledge.

The participants of this study ranged from a second grade level of cognition and comprehension to sixth grade, with the majority of them right at or slightly below fifth grade. No matter the level of the student, each added to and benefited from the discussion. Student-led discussions became an essential part of the unit because the teacher/researcher had little or no knowledge of specific cultural references, which allowed students to better comprehend the material. A key element that made this unit successful was the range of abilities (i+1 and ZPD) of the students, which provided scaffolding.

During an informal interview with the students, they were asked what they liked about this unit. Sherlock exclaimed that he really enjoyed this unit because it was more self-directed and because he was able to use his previous skills in different ways. Self-expression and personal choice were recurring factors cited by the students as to why they preferred the integrated unit. However, Buffy mentioned that while she enjoyed the unit and learned a lot, she still likes some classes to focus on one subject or skill.

Students were also asked why they did or did not like certain subjects. The overwhelming response was the subject was irrelevant— “it does not matter.” Another answer was that the subject was “too hard.” Further inquiry resulted in the discovery of fixed mindsets. If it is too hard then I must not be good at it and I never will be (Dweck, 2006).

Limitations of This Study

The small sample size in this study limited the ability of the researcher to come to a generalized conclusion. In addition, the fact that only two of the seven students were present for the entire unit further complicated data collection. Additional research, with a control class of

25-30 students of varying economic and ethnic backgrounds and a comparable treatment group, is required in order to prove the benefits of integrated instruction.

When planning an integrated unit, it is important to build relationships with students in order to bring relevancy and meaning. However, as educator/researcher, I found that students had a severe lack of both tangible and intangible cultural heritage and knowledge. I was unable to determine what would truly make the study meaningful and relevant for this group of students because the students were unable to communicate their values and beliefs.

Conclusions and Future Study

This study showed that the integration of two or more subjects did increase engagement and generate deeper understanding. The social interaction that occurred during this study revealed how peer-to-peer interaction increased understanding and engagement; students were able to communicate their learning in language readily understood by the others. Each time new information and understanding came to light for students, they shared their excitement with the class, which in turn created higher levels of engagement for everyone.

This study also provided this educator/researcher insight into the need for students to recognize and understand their own culture and heritage. Many students simply claim to be American, but do not understand what that means for themselves or others. Since none of the students knew the "ground" upon which they stood, it was difficult to find common ground. If common ground could have been found, the unit could have been altered to make instruction more relevant to the individuals involved.

Maintaining and sustaining engagement was difficult the last few days of the unit. On day eight, students began to lose interest. There were two likely reasons for this: lack of relativity/meaningfulness and requirements were already met. Lack of relevancy and

meaningfulness communicates the need to go back to student biographies and requires the educator gather more data regarding student preferences and interest as well as seeking new ways to promote social (peer to peer) interaction and excitement. The second reason, students had met the requirements, brings up more questions. What should be done when a student completes the assignment early? Should focus be on an end product? Or, does having an end product stifle learning because the student is simply looking to meet the teacher's expectations? Should the unit, instead, be built on process? If the unit is process oriented, then how can one engage the students who need a conclusion? It will only be through the building of relationships with students and continued research that these questions can be answered.

Building relationships is the most important part of teaching. Students need to be able to feel secure in their classroom, and that can only be accomplished through robust relationships.

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Tables and Figures

Figure 1- How the Brain Processes Sensory Inputs

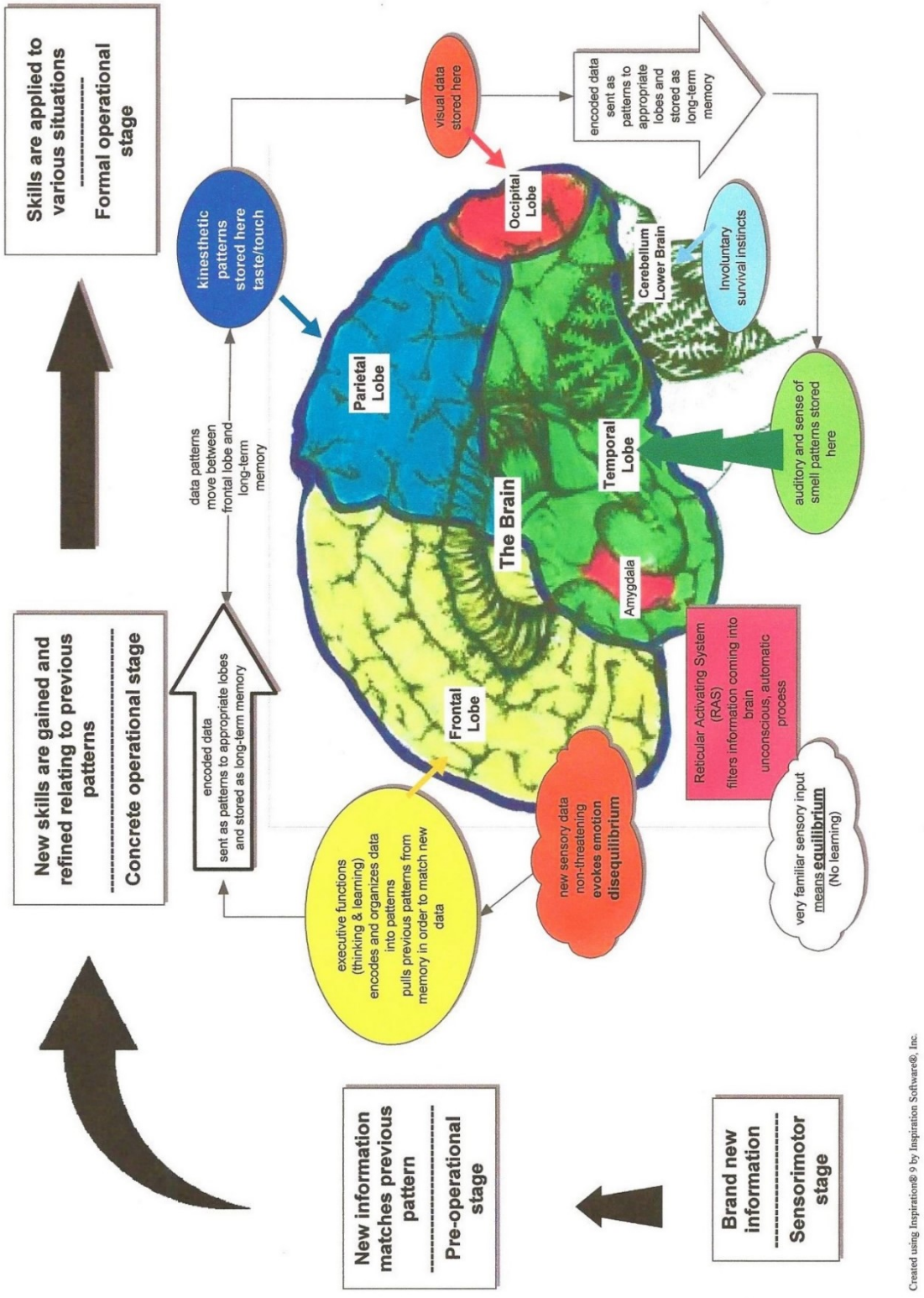


Table 1 - Student Responses Pre and Post Regarding Social Studies and Math Lesson of "Ten Black Dots and September 11"

Original Comments	Comments after learning
• Terrorists flew planes into the buildings in New York. • People ran out of the buildings screaming. • Lots of people died.	After reading *September 11, 2001: Attack on New York City* (Hampton, 2003): • It was a bright clear morning in New York on September 11th. • The tower that was hit by the second plane began to fall first. • The hijackers turned the planes into flying missiles.
	After reading *Ten Black Dots* (Crews, 1968): • Ten (10) black dots are the windows on the first tower that was hit by the airplane. • One (1) black dot shows the nose of one of Flight 77 that flew into the Pentagon. • Eight (8) black dots stand for the eyes of four children who are crying because their parents died on September 11th

Adapted from Kinniburgh & Byrd (2008).

Figure 2 – Boom and Bust Social Studies Unit

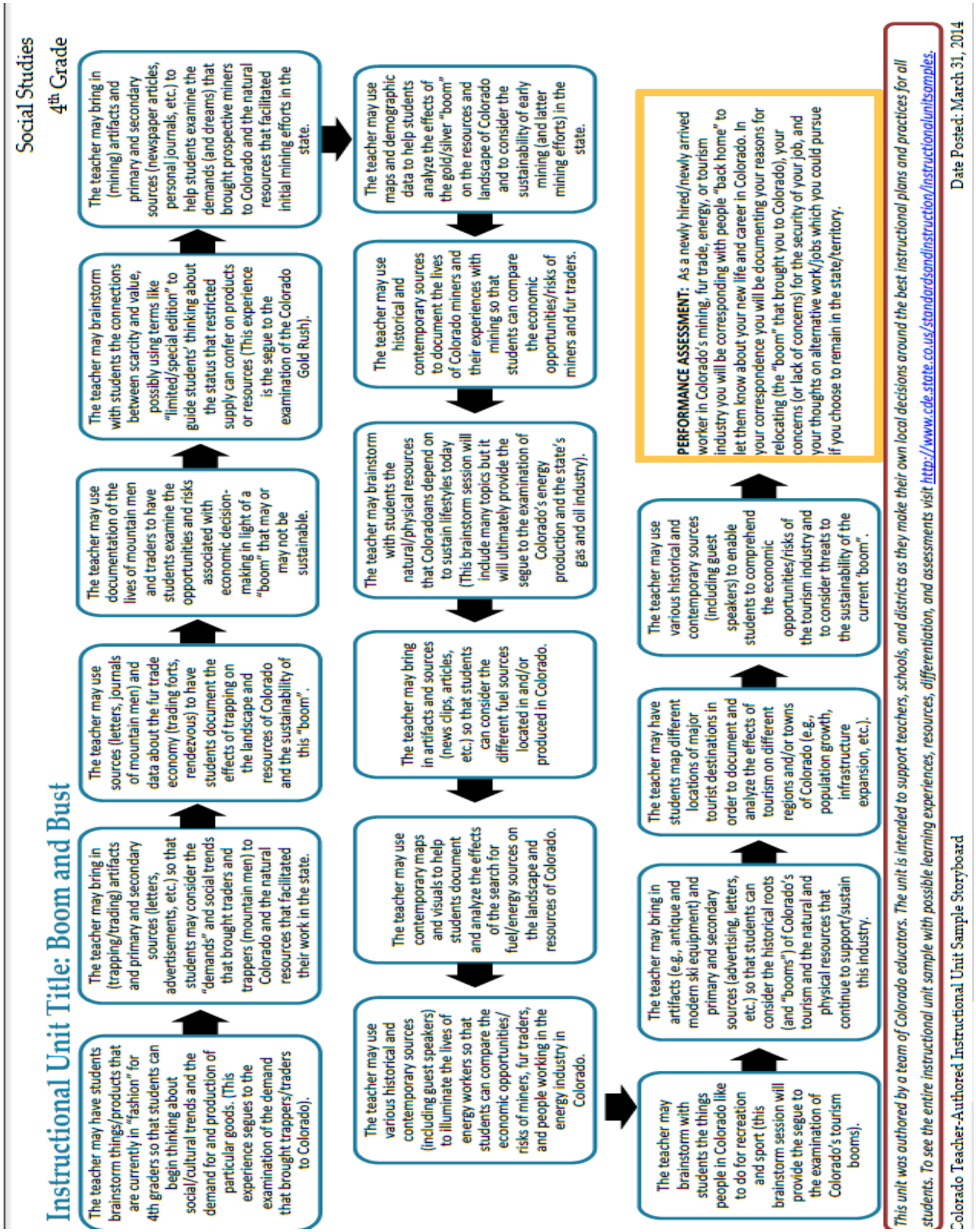


Table 2 - Criteria for Assessing Engagement

Criteria for Assessing Engagement		
Level	Engagement	Further description
1	Disengaged	not participating
2	Participating reluctantly	simply following directions, but often off topic
3	Participating most of the time	sometimes off topic
4	Participating	asking simple questions and adding some to the discussion; stayed on topic
5	Actively engaged	asking higher level questions, adding new information to the discussion

Figure 3 – Test Scores

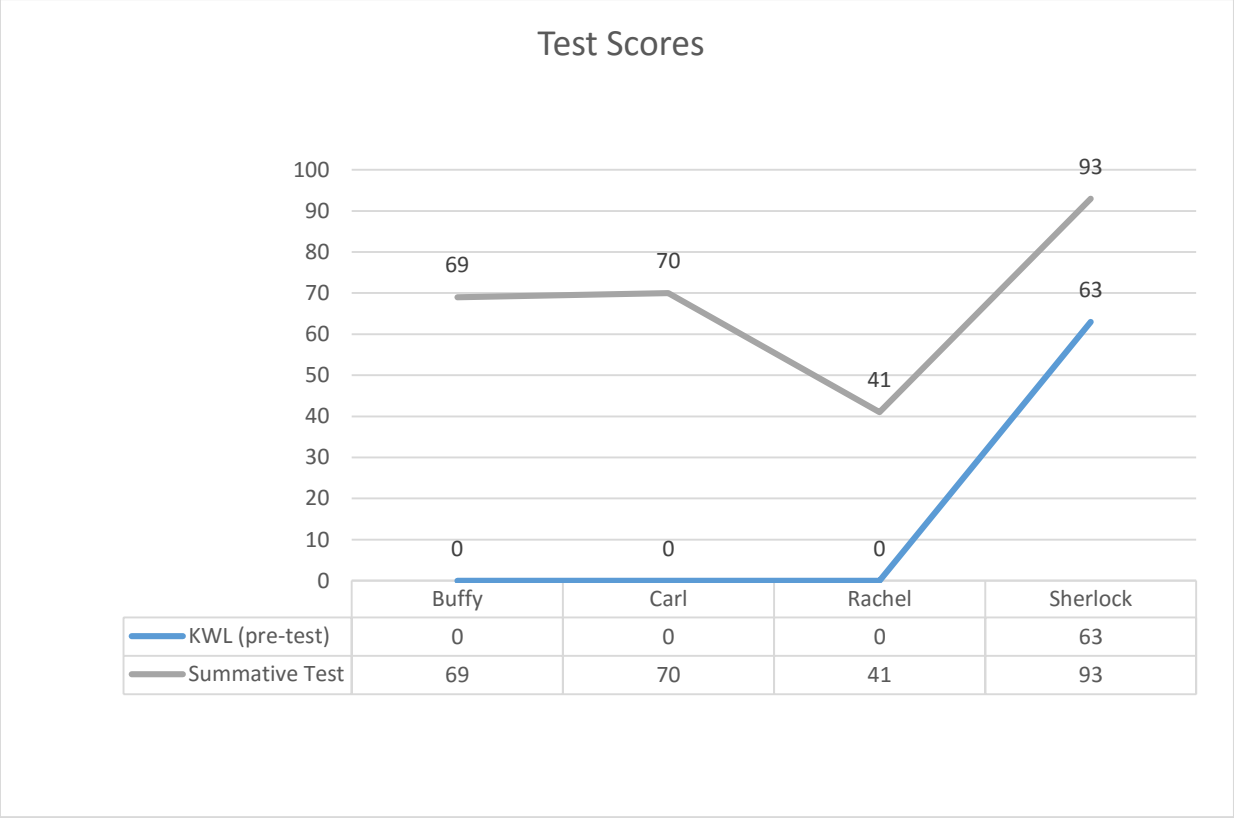
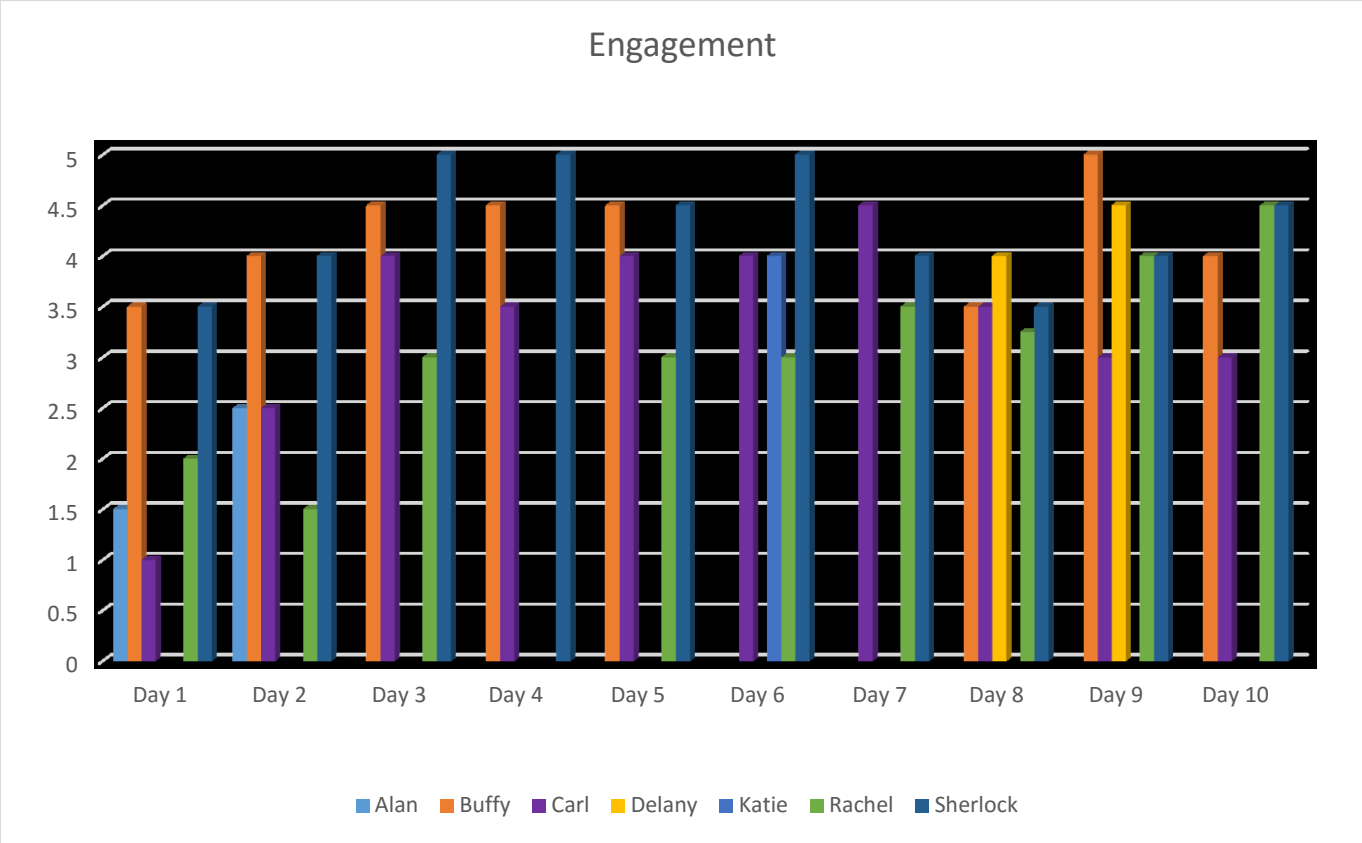


Figure 4 – Engagement Data



Appendix A

Name_____ Date_____

What is your interest level in math?	Not Interested	Slightly Interested	Interested	Very Interested	Completely Interested
What is your interest level in science?	Not Interested	Slightly Interested	Interested	Very Interested	Completely Interested
Is math useful for you?	Not Useful	Slightly Useful	Useful	Very Useful	Completely Useful
Is science useful for you?	Not Useful	Slightly Useful	Useful	Very Useful	Completely Useful

Do you like math? Yes / No
Why?

_____
_____
_____
_____

Do you like science? Yes / No
Why?

_____
_____
_____
_____

Appendix B

Name_____
Date _____

Outer Space and Cyber Space

Diagnostic Assessment

K - W – L

In each box write what you **know** and **want** to know. As you learn new things, you will write what you **learned**. Write at least **5** characteristics of each planet listed. (SC.E.1.2.4.4.1)

K What do you **know**?	**W** What do you **want** to know?	**L** What did you **learn**?
Jupiter	Jupiter	Jupiter
Saturn	Saturn	Saturn
Uranus	Uranus	Uranus
Neptune	Neptune	Neptune
Pluto	Pluto	Pluto

K What do you **know**?	W What do you **want** to know?	L What did you **learn**?
What keeps the planets in the same order as they move around the sun? (SC.E.1.2.5.4.1)		

Look at these numbers. Fill in the blanks with the correct answer. (MA.E.1.2.2.4.1)

6, 2, 6, 1, 5, 6, 2

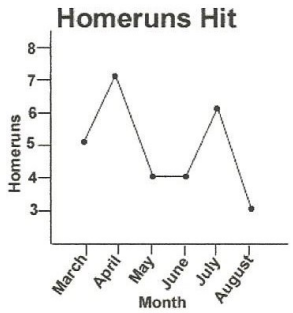
The **median** is _____.

The **mode** is _____.

The **mean** is _____.

Look at this line graph.
(MA.E.1.2.2.4.2)

The **range** is _____.



Use a calculator to find the range and mean of these numbers. (MA.E.1.2.3.4.1)

3, 5, 7, 3, 2

The **mean** is _____.

The **range** is _____.

Write a sentence to answer the question. (LA.B.2.2.4.4.1)

What could electronic technology be used for?

Turn the paper over and write a paragraph about the sun. Remember to focus on the topic, give facts to support your ideas, and use a variety of sentence structures. (LA.2.2.6.4.1, LA.B.2.2.6.4.2, LA.B.2.2.6.4.7)

Appendix C

Student Biography Cards	
Student:	
Name: Age: Grade: Country of Origin: Time in USA:	Sociocultural Dimension Home + Community + School= Background Knowledge
L1: R: W: L2 Proficiency (LAS/IPT/Other): O: R: W: SLA:	Linguistic Dimension Valuing L1 & L2
Student Processing: Learning Style: Prior Academic Experiences:	Cognitive Dimension Implications for Practice
Preferred Grouping: Other:	Academic Dimension State of Mind
School Situated	Biography Situated

Appendix D

Summative Test – 4 pages

Name _____
Date _____

Planets in Orbit

Summative Assessment #1

Write at least 5 characteristics of each planet listed. (SC.E.1.2.4.4.1)

Jupiter
1.
2.
3.
4.
5.
Saturn
1.
2.
3.
4.
5.
Uranus
1.
2.
3.
4.
5.

Neptune
1.
2.
3.
4.
5.
Pluto
1.
2.
3.
4.
5.

What keeps the planets in the same order as they move around the sun? (SC.E.1.2.5.4.1)

1. The force is _____.

2. The movement around the sun is called _____.

3. Tell how this force and movement work together.

Write the correct answer to each question. (SC.E.1.2.4.4.1, SC.E.1.2.5.4.1)

1. Which planet is furthest from the sun most of the time?

2. Which plant is largest?

3. Which planet has the most satellites (moons)?

4. Which planet is coldest?

5. Which two planets are very much alike? (They are close to the same size. Their temperature is very close. Their rotation period is very similar.)

6. Which planet takes longest to rotate around the sun?

7. Name **one** of the two planets that have a stronger known gravitational pull than the Earth?

8. Which planet has the most rings?

9. What force holds the planets in their orbit around the sun?

10. What is an orbit?

11. Earth's moon only revolves around Earth. Why?

12. What shape is an orbit?

Name : _____ Score : _____

Teacher : _____ Date : _____

Mean, Mode, Median, and Range

1) 16, 12, 12, 12, 20, 17, 16

Mean ____ Median ____ Mode _____ Range ____

2) 8 , 9 , 12, 19, 6 , 19, 17, 14

Mean ____ Median ____ Mode _____ Range ____

3) 15, 9 , 17, 8 , 15, 13, 7

Mean ____ Median ____ Mode _____ Range ____

4) 17, 20, 17, 6 , 20

Mean ____ Median ____ Mode _____ Range ____

5) 14, 9 , 8 , 12, 13, 11, 17, 14, 19

Mean ____ Median ____ Mode _____ Range ____

6) 17, 14, 19, 7 , 8

Mean ____ Median ____ Mode _____ Range ____

7) 6 , 16, 8 , 12, 16, 20

Mean ____ Median ____ Mode _____ Range ____

8) 8 , 10, 5 , 8 , 19

Mean ____ Median ____ Mode _____ Range ____

9) 20, 9 , 16, 10, 14, 10, 18, 14, 15

Mean ____ Median ____ Mode _____ Range ____

10) 15, 6 , 10, 14, 6 , 7 , 16, 6

Mean ____ Median ____ Mode _____ Range ____