Why Does Place Value Matter?

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Introduction

The objective of this unit is for my fifth grade students to be able to apply their understanding of place value to the millions place, estimate, multiply and divide by 10s, and to extend the numerical patterns exponentially, thus understanding the numerical value and the significance of increasing place values. The goal is for students to be successful at understanding problems and solving them. Through numerous conversations with fellow colleagues, latest readings and research, solving problems seems to challenge students at every grade level. Since this skill is so significant, prevalent, and evident in multiple aspects of our lives, I am framing this unit with Poyla's classic framework for problem solving. This framework, or process, has four basic steps. First, understand the problem; as our objective and goal was mentioned earlier. Second, make a plan; which includes the components and strategies that will play a role in solving the problem. Third, carry out the plan; also known in this unit as the Activities. Fourth, look back, check, and verify; the final phase of the activities that will reflect acquired learning.

To make a plan, I will take to take the comprehensive approach of Problem-Based Learning (PBL). There are many sound reasons that support this approach such as; enhanced motivation, integration of practice-oriented competencies, improved retention of students, augmentation of the quality of education, and collaboration. Simply stated, the students will have such a variety of opportunities to see and apply this skill that their conceptual understanding will deepen and solving problems will become more intuitive. The PBL method weaves and blends the content and standards across the curriculum thus making connections and sense of realistic situations.[1]

The PBL model has many definitions and comes in a variety of formats. For the purpose of this unit, I have designed the model to include four major components; Content, Group Work, Research, and Mindset.

First, the math content will be scaffolded and presented through a variety of curriculum and online resources such as; Math Trailblazers, Engage New York, Math Illustrations, National Library of Virtual Manipulatives, and Smarter Balance Tasks. Instruction will be differentiated and content from other subjects will be incorporated to enhance and deepen the students' understanding of the significance and value of the math concepts introduced.

Second, the group work will build collaboration, flexibility, and creativity. Throughout the unit the students will be asked to think, do, and share. They will be looking for multiple strategies to solve problems and to confirm their answers. 'Number Talks' is the open discussion strategy and forum that will be modeled throughout.

Third, to further synthesize their learning, the students will be asked to research a topic that will incorporate what we have been discussing in class across the content areas, such as; endangered animals in reading, ecosystems in science, due process and law reform, i.e. the Endangered Species Act. This act was created to protect the rights of specific animals from extinction. Students will gain the understanding of how numbers and their place values play a significant role as a critical component in proving evidence and perhaps a call for action.

Fourth, the final component will help develop an open mindset which means positive work and mind habits, such as perseverance, hope, determination, and pride in personal and team accomplishments. (Although this unit is intended for my fifth grade class, it can be easily modified or extended for higher grades.)

To carry out the plan, the Unit will facilitate learning in the Number and Operations in Base Ten Domain. Each of the unit's three Activities will focus on a specific Common Core State Standard: (#1) to recognize the value of digits in specific place value positions, CC.5.NBT.1; (#2) to understand the multiplication and division process of 10 and a number by powers of ten, CC.5.NBT.2; and (#3) to round, estimate, model, and scale with concrete drawings, manipulatives, strategies based on place value, properties of operations, and explanations through calculation, CC.5.NBT.3.4.6.

To verify student problem-solving skills and strategies, the final task will require students to investigate a problem, analyze the plan in place, and decide if it truly is successful based on numerical data and environmental results. In conclusion, students will improve the solution, piggy-back, or create an alternate solution with justification.

Background of the School and Students

Currently, I teach fifth-grade in a self-contained classroom at Brandywine Springs School (BSS), Wilmington, Delaware in the Red Clay Consolidated School District (RCCSD). Red Clay includes the northwestern sections of the City of Wilmington and its suburbs, all the way to the Pennsylvania state line, from the Brandywine Creek to the Pike Creek Valley area, and along the Christina River back to the city line. Red Clay is the 2nd largest public school district in the state. The district serves more than 15,000 students in fourteen elementary schools, six middle schools, and five high schools, four special education schools, and three charter schools.

Brandywine Springs School is unique in that it is the only school in RCCSD to include K-8 with a population of approximately 1,100 students. The population is 83.7% Caucasian, 6.3% Hispanic/Latino, 4.9% Asian, 3.8% African American, and 16.3% low-income families. In the lower and intermediate grades there is an average of 5-6 classes per grade. Each class contains 22-27 students. BSS is situated in a suburban neighborhood and abuts the New Castle County Recreational Park. BSS offers excellent educational opportunities to all of the students who come to our school from a variety of home situations and academic levels. Our core instructional program is aligned to the Common Core State Standards, and our highly qualified teachers differentiate instruction to meet the individual needs of all the students.

Rationale

We have seen that the new Common Core State Standards for Mathematics (CCSSM) have revamped the educational domains and areas. They are lean and explicit which will give teachers more time to go deeper into their meanings as well as application. The shift requires focus, coherence, and rigor. These are imperative elements of change and will have a positive impact on student learning in the classroom. [2]

Math practices in the classroom will also require both students and teachers to refine their thinking and utilization of strategies and tools as they work through these major shifts. This attention to detail and 'tweaking' of lessons will have other benefits as well. Across the grades, giving attention to math practices such as; precision, tools, patterns, perseverance, argumentative thinking, modeling, and reasoning abstractly and quantitatively - will help to bring focus to purposeful applications, creative thinking, and innovative solutions.

On a larger scale, this unit has been designed to meet, engage, and challenge each student as specified by the guidelines of the Common Core State Standards. It will be particularly significant to our students since our main initiative is to equip them with 21st century skills and tools. They are the future designers and collaborators of tomorrow; making our future environmentally safe, eco-friendly, and culturally sensitive on a local and global scale. This unit will incorporate multiple dimensions of the latest mathematical research and resources to help students achieve their highest potential.

At the Red Clay District level, we will be receiving monthly professional training for both Common Core Reading and Math. This will allow teachers' time to delve deeper to discuss and understand the major shifts of the new Common Core State Standards. It will also help us to utilize new materials effectively and successfully with our students. The current educational practices and resources from this professional development will be integrated into this unit.
On the school building level, we are also focusing on strategies to support problem solving and critical thinking. The Building Leadership Team, of which I am a member,

will present a series of Differentiated Instruction (DI) strategies sessions during our monthly faculty meetings throughout the year. These sessions will include various models of student engagement, questioning, flexible grouping, and ongoing assessment. In addition, the Professional Learning Community (PLC) team meetings will discuss how to purposefully and successfully apply the mathematical practices, develop formative and summative assessments, and analyze student data to determine teaching strategies across the grade. Insights and strategies from these group discussions will be woven into the instructional fabric of the unit.

Personally, I have completed an on-line course, *How to Learn Math,* presented by the renowned professor and author Jo Boaler of Stanford University. The course considers the student's mindset and how to attain higher levels of engagement resulting in higher levels of achievement. Jo Boaler referenced an abundance of the latest research and authors in this course. I look forward to including these findings as well as incorporating this rich knowledge into my best practices as an educator.

Problem Solving

Step one is to 'Understand the Problem.' From my relentless conversations with other professional educators, I know I am not alone in the conversion challenges to the Common Core. On one hand, it is a blessing that we can take more time to delve deeper into a subject and enrich learning in these areas. But on the other hand, the layers of recommended targets, resources, and strategies can make one overwhelmed and dizzy, like being tossed about by ceaseless hurricane winds that just won't stop!

My mantra is to "Stop the madness!" Let's "use what we know" works and work smart. Let's review all the research that has been done to move us forward and weave the new 21st century workplace challenges into our new field of dreams. So I have taken this opportunity to gather my spinning thoughts and quiet the storm. Please indulge me, as I proceed to make sense of our educational world, to find a solution and make each day a day of insightful challenges as our passion drives us forward to teach as our hearts would have us do.

First, stop, step back, and think about all the multi-tasking we do in our lives to keep our family and home in balance and in check. We can accomplish tasks that are completely different but yet require common strategies to reach completion. Can we make a list for the grocery store as well as for packing for a trip? Yes! Can we do a Ben Franklin list to help us decide which couch or car to buy? Yes! Can we use a cause and effect chain to help us understand how problems arise and how we can avoid them in the future? Yes!

Terrific! Now, we know that with the fast moving technological changes we don't know the jobs our students will have in the future. We can only anticipate and prepare

our students with what we know and can anticipate. So let's start there. Let's begin with what has been researched and well documented; the 21st century workforce will need to be fluent thinkers, problem-solvers, collaborators, debaters, and organizers. This sounds like a very similar set of skills we just mentioned in the previous paragraph! Hmmm… I think we can do this!

Now it's time for step two, 'Make a Plan,' with the end in mind, these 21st century skills will require (1) proficiency in specific content knowledge, (2) versatility in both independent and interdependent collaborative situations, (3) competency in research and data analysis, and (4) a positive mindset which, pervasive in nature, influences one's dedication, passion, and perseverance in the workplace.

Proficiency in Content:

Everyone has content, material to be covered and assessed. How do we gain the attention of the students to really learn and go deep? The answer is to make it authentic, engaging, organized, and procedural.

Be Authentic

We know that new learning must access our schemas, or previous experiences, and then be applied to something real in the present. This type of transference is one of the biggest challenges for an educator. It is one thing to learn material for the test, yet another to apply it in the real world! So, can the students help? Of course! The answers lie in your students and in the classroom synergy! It's most effective to integrate specific math objectives with both social studies and science content. For example, in social studies, my students will be studying about immigration and population growth, and economics. By applying new place value concepts and skills into this content, they will have greater understanding of the significance of the impact of "big" numbers. Also, in the sciences, topics such as earth materials, physics, and chemistry will also include using numbers with meters, centimeters, and millimeters, which are all based on the decimal system. In addition, futuristically, STEM initiatives will demand this type of mathematical fluency as well. Therefore, the more students see direct applications of numbers in everyday situations, the greater their ability to make personal connections and truly learn.

Be Engaged

Students are engaged and actively learning when they are the ones <u>doing</u>. They need to be actively solving the problems, applying what they're learning, and asking the questions. By manipulating the content, they will make meaning and sense of it.[3] Studies have found that when students are engaged in conversation and discussions with others, they retain more information. Simply put, when students are interacting with others, they are more engaged, as are their brains.[4] So, can we get the students engaged by moving and

learning kinesthetically or with strategic grouping? Sure! The dynamics created by weaving in carousels, jigsaws, think-pair share, partner sharing/teaching, dramatizations, snowballs, voting with your feet, and music and movement can energize and accelerate learning and retention best of all!

Be Organized

Being organized can be thought of as a means to making sense of and aligning all that is in our environment. It is through organization that many pieces have a place and fit together, thus becoming understandable. It is through understanding that we can then look at other situations and interpret their meaning and significance. Thinking maps, also known as mind maps or graphic organizers, can be used to organize these facts and information into a structural format and thereby revealing consistency and patterns in our environment. This organization helps our brain to interpret, store, and retrieve information easily and in a way that makes sense.

Advanced graphic organizers, are the same type of thinking map but used before a lesson. First, the teacher presents a situation that can be categorized or organized in a specific way, i.e. compare and contrast, sequencing, concept mapping, cause/effect, etc. Once the student has had an opportunity to access his/her thinking to a common, real-world situation, he/she will be ready to apply and organize the grade-level challenge of the lesson in the same format. This type of warm-up allows the students to not only access prior knowledge and/or experiences, but to achieve understanding through parallel processing of the graphic organization. "Once there is understanding of the conceptual reasoning for this pattern, the students can then network connections to numerous other concepts and challenges.[5] This process is integral to the learning process for it enhances recall accessibility and results in significant learning gains.

Four Phases of Problem-Solving

Today, our focus, our challenge is to facilitate skill development in solving problems, while striving for creativity and innovation. The application of these specific steps, or phases, as noted by Poyla, will increase student proficiency as students learn to apply them purposefully with each problem or situation that arises. Following are the steps the students should follow:

(1) Understand the problem: by reading the problem multiple times, each time gaining greater understanding of the big picture, the details and what the problem is asking.

(2) Make a plan: Picture it, draw it, and pick a strategy. The human brain is triggered by visual stimulation to accesses multiple areas to solve the problem. Next, is to imagine the situation and determine the algorithm needed to solve the problem. Visual representation also helps later in the confirmation stage.

(3) Carry out the plan: estimate, and calculate. As students see the problem, ask them to estimate, or predict what the answer might be. This inserts another opportunity to check for a reasonable answer. Now carry on with the actual mathematical equation(s) to find the solution. Can the problem be answered by a second strategy? Does the new answer agree with the first answer?

(4) Look back at your work and ask: does it make sense? Is it reasonable? Does the answer come close to your estimation? Check your work, what kind of improvements can you make?[6]

Versatility for Working Independently and Interdependently

Working with others encourages shared learning. Challenge the students by proposing practical applications or problems related to the subject content. But before they join a partnership or team, allow students to think on their own. They should feel personal 'ownership' of their own thinking! Then set them on a course to be creative and cooperative in a small group setting. In Jo In Jo Boaler's online course, How to Learn Math, she quotes, Innovation and Invention writer and researcher, Peter Sims, from the NY Times, "…entrepreneurs and design thinkers and problem-solvers emerge from wild ideas, feel comfortable making mistakes, withhold any pre-judging of ideas, and are always willing to try a new tactic**.**

Therefore, as we set this type of brainstorming in motion the students need to be respectful, receptive, and ready to collaboratively work together. This means that the process may require some scaffolds. In the beginning, group members will have assigned roles, such as, the getter of materials, the facilitator, the writer, the illustrator, and the reporter. These assignments can rotate over time so the students will have the opportunity to experience the responsibility of each role.

Also important, is to allow time at the end of each class to discuss not only the strategies and answers to the problem/challenge, but the dynamics of the group. Sometimes, the group dynamics work well and other times there are problems that hinder the problem solution process. These are all important dimensions of the process that need addressing. These situations tie into the power of our personal or group "mindset" which will be discussed below. As a result, this exercise allows for students to arrive at the understanding that the environment and personal commitment to solving issues or problems go beyond paper and pencil. They then will be ready to set "norms" for group work, whereby agreeing on positive behaviors and responsibilities encourage a successful collaborative experience and outcome.

Competent in Research and Data Analysis

We live in an information age. If we do not connect our classroom learning with seeking more information to enhance, explain, justify, or debate, we are doing our students an injustice. To inspire question asking and seeking to answer the "I wonder?" and "why?" questions is giving them license to own their own learning. Therefore, when the students are working with a partner or group, ask them to ask why. "Does it make sense?" This will develop the questioning state of mind and the habits of the mind to inquire. On the flip side, the student needs to be able to defend their thinking and be precise in their explanation(s.) As students refine this process and transfer it to their own thinking patterns, their personal learning will takes off! To further support this direction, students should take Internet Safety classes and have been taught in technology class, or in the general classroom, how to research properly and appropriately. A summative transfer task can be given to incorporate together multiple skills, content areas, and an opportunity to synthesize, analysis, and create to demonstrate their higher thinking achievement.

Positive Mindset

The next area is the most influential ….positive energy….an open mindset! This energy can make or break any kind of learning. Positive words, gestures, looks – all drive learning forward and have great intrinsic motivational power. Whereas, negative comments, frowns, disregard for differences - all of these can destroy the best of lessons and intentions. Building a safe environment to share, explain, ask, listen, or make mistakes is imperative! Carol Dweck states, "Every time they make mistakes, they grow a synapse! Aha! Making mistakes is useful!" In addition, research done by Jason Moser, shows significant growth occurs in an open positive mindset than in a closed mindset.[7] This is also substantiated by Erna Yackel, who states, "…years of research continue to show, such as the finding from both Labinowicz and Von Glaserfeld and remain applicable is the fact that children's errors are a natural and necessary part of conceptual development. By figuring out why something is an error, a child can make progress in understanding."[8]

To enhance this positive aspect of the PBL model/unit, we are connecting the theme of our reading series which is "Doing the Right Thing." These stories explore various situations in which the main character discovers human frailty and how our words and actions impact others around us, as well as the consequences that are set into motion. As students read, experience, and make connections between characters in a book and/or people, both present and past, and the events that followed. Is it our hope that they will arrive at the understanding of the influential power of a positive mindset, or attitude, and the resulting successes bound to follow.

To Conclude

These dimensions of learning and cooperating in the classroom, school, or workplace are all very real. Our goal, as teachers, should be to be cognizant of all of these components, and to creatively incorporate as many of them that apply each day. Regarding subject content, try to make connections from one subject content to another, so it all makes sense to the students. We work on multiple levels of social graces, manners and consideration in every subject. Flexible groupings are encouraged for varied dynamics and learning opportunities. Finally, after careful scaffolding of independent, partner, and group work, independent learning groups will begin. As In summary, the Project/Problem based approach develops skills to solve authentic problems which impart social, technical, and methodical skills. Consequently, with all of these supports of positive experiences, and opportunities of individual learning, students will be intrinsically motivated.[9]

As I discuss my unit, I will share the Common Core Goals that guided my curriculum, the depth of the expected learning, followed by authenticity and application. Since the beginning of the year, I have scaffolded learning experiences to help my students become good independent learners, partners, and group members. Of course, this is always a work in progress as it is in every classroom. The reward is watching them grow as we, the teachers, practice patience and perseverance to help our students reach their highest potential.

Mathematical Content for Place Value

Expanded Notation

Expanded Notation is the breaking-down of a number to each place value. It breaks down a number by identifying what each digit represents based on the place value which it's in, for example: 1,459,236 = 1,000,000 + 400,000 + 50,000 + 9,000 + 200 + 30 + 6. By unpacking a compressed number, it emphasizes the place value concept and thus increases the conceptual understanding of the actual size of the number. In addition, students will achieve greater flexibility of thinking as they will be required to estimate and compute with larger numbers.
After identifying the actual number value, the students will be asked to further decompose each number in each place value by the power of tens. For example the example above will become: 1,459,236 = (1 x 1,000,000) + (4 x 100,000) + (5 x 10,000) + (9 x 1,000) + (2 x 100) + (3 x 10) = (6 x 1). By representing each place value as a digit multiplied by its place value, or power of ten, it further develops understanding of the systematic patterns within the number system. As Diane Yackel states succinctly from her research, "This conceptual understanding of how and why ranking ordinal units of ones, tens, hundreds, etc., occur is foundational to student understanding and success in addition, subtraction, multiplication, division, and onward."

Estimation

Rounding to the nearest place value: The students will be required to use their place value knowledge and apply it to a number line. During this phase of the unit, they will apply their understanding of a number line from third and fourth grade where they segmented the number line by tens and hundreds. Now, they will segment the number line by thousands, ten-thousands, hundred thousands, and millions. The most frequent mistake I have seen in this process is when students round to the nearest ten-thousand, they round the one thousand place and then put the rest of the digits back into the number. For example: the number 123,456 is rounded to 120,456. They forget that all the digits will have a zero as a place holder in all of the place values to the right of the ten thousand place value. I have corrected this conceptual misunderstanding by having students reanalyze the 100/200 chart, observe and create number line segments on interactive number lines, as well as by looking at examples on graphs and time lines.

Estimation is also a lifelong skill when computing large numbers in the real world. By visiting stadiums, population growth tables, production costs, etc…the students have an immediate appreciation for applying this skill! We had a multitude of opportunities to apply estimation, or rounding, to everyday situations. This type of conceptual understanding increases their ability to think on a large scale and to be flexible with their mathematical strategies.

Decimals

Decimals – fractional worth: At this point of the year, we will be discussing decimals as 1/10 the value of the number to the left place value. Just as; 10 is 1/10 of 100 (100 x 1/10, or 100/10), and 1 is 1/10 of 10 (10 x 1/10, or 10/10), likewise, So .1 is 1/10 of 1 (1 x 1/10, or 1/10) and .01 is 1/10 of 1/10, or 1/10 x 1/10) which equals $1/100^{th}$. This gets very tricky to teach and very easy for the students to get confused. Modeling with ones, tens, hundreds, or pennies, dimes and dollars is a more concrete method for students to gain a conceptual understanding of this principle. As soon as we started talking about money and shopping, my students' learning took off and they were creating word problems and estimating with decimals in no time!

Exponents

For the final challenge in our unit, I introduced powers of ten, or exponential numbers. To set their mindset, I showed them the video of "Power of Ten," a classic video that take the viewer from a picnic in the park to the outer galaxies our universe and then back and beyond to the atomic level of a molecule inside one's body. Once the stage was set for why they're learning powers of ten, my students were eager to be scientist among the stars or doctors at the microscopic level!

Next, the students took their understanding of place value and broke it down to powers of ten. For example, 100 = 10 x 10 = 10 to the second power, 1000 = 10 x 10 x 10 = 10 to the third power and so on. The students then took this understanding and apply it to a number such as 300,000 and transpose it to 3 x 100,000 = 3 x 10 to the fifth power. Once the students were able to express a large number such as this one noted above, they could learn how to multiply this number by 10 (300,000 x 10 = 3,000,000 = 3 x 10 sixth power) or two numbers such as 300,000 x 200,000 = 6 x 10 to the 10th power! Which looks like this…. 60,000,000,000…WOW! Now we're talking big numbers!

Strategies

Teaching is Learning

The Harvard Calculus Consortium endorsed the Principle of 4. This states that every situation should be described in at least four ways: (1) words, (2) pictures, (3) graphs, and (4) tables.[10] Therefore, as educators we must encourage our students to incorporate these methods as they solve mathematical problems. Each form will access parts of the brain which then creates conceptual networking as it enforces procedural knowledge and number sense. Joan Boaler shares, that according to the latest research, at Mount Holyoke College, concerning retention of information and conceptual learning, it has been found that the brain retains:

10% of what we read,
20% of what we hear,
30% of what we see.
50% of what we both see and hear,
70% of what we discover,
80% of what we experience, and
90-95% of what we teach!

Following are some strategies that can be used for differentiated learning purposes:

Number Talks

It is most important to create a non-threatening, safe, environment of learning in your math class. Research has shown that math class is one of the most stressful and scary classes that learners remember for years. The fear and stress factor closes down one's creative thinking process fast. The classroom environment should allow for varied thinking strategies, authentic real life situations for personal connections and entries of learning.

"Number Talks" is a highly effective teaching strategy which involves presenting a math objective with a model and think-aloud, followed by a task in which the students

will work individually and then with a group to share their thinking strategies. This is then followed with presenting the solution by either individuals or the group to discuss the various strategies which were used to solve the task.[11]

Teachers must also be intend listeners to be truly effective. First, we must hear what the students say. Second, we need to make sense of it. What do they really mean? How are they arriving at the answer? How are you going to respond? [12]Or ask another higher-thinking, an extension/posing question for students to consider. This approach allows: the opportunity for a balance of both individual and group responses; maintaining respect for differences of thought; and monitoring by the teacher to stretch, pose, or guide the class into an appropriate direction in a non-threatening manner.

This format of Number Talks can also be used to solve authentic word problems. Students will continue to develop flexible and versatile thinking. Subsequently, their learning will; go "deep," realizing alternate routes to achieve an answer, and gain additional strategies for future challenges.

Another concept that should be added and realized is that it is a natural phenomenon of our brain to seek short cuts or compress our learning. Sometimes this compression needs guiding and scaffolding. As Jo Boaler researched and restated from the works of William Thurston, "Students who don't engage in conceptual mathematics do not benefit from compression."[13] Therefore, it's worth the time to spend on conceptual understanding rather than only on the procedural. I know I have to restrain myself when I hear students explain how someone showed them a trick to do it faster and they have no understanding of how or why it works. There's no transfer of skill here.

Carousel

This strategy requires a word problem or question at a station. The class is divided up into groups. The groups travel from station to station adding their thinking onto the previous group's contribution. Each group has their own colored marker so you can see how and what each group added to the problem. Students enjoy doing the carousel because it gets them up and moving and they get to make a mark on the overall class solution. At the end of the rounds, there is a class discussion of their thinking similarities and differences.

Jigsaw

This strategy is a group activity where each group has one focus or challenge. After they agree on the answer or content, the groups switch so that there is one representative from each group in the new groups. Now each individual in the group is responsible for teaching or presenting the material to the members of the new group. For example: aaaa bbbb cccc --> abc abc abc abc

High Low

This strategy of matching partners is beneficial because it's a win-win situation. The high students are competent in the skill and get the added benefit of teaching it to a classmate. The low student needs to hear the math challenge explained from a student's perspective and language. Sometimes the low student just needs to hear it one more time, or from a friend, either way it is a good opportunity for learning. Of course these teaching pairs need to be made with discretion.

Additional Differentiated Instructional Strategies

Pen/Paper/Whiteboards: The students can use pencil and paper to write numerically and to sketch the visual picture of a problem and to describe their thinking and reasoning.

Base-ten pieces: Base-ten pieces or cubes enable students to model or build. This tactile/kinesthetic approach helps the students to feel a concrete model of the numbers. The digit flip chart is also helpful to use as numbers are multiplied and divided by 10.

Number Lines: Using number lines offer students the opportunity to understand the proximity of numbers and how the process of rounding or estimating a number is determined. They are a good visual aid to illustrate how numbers of different sizes or amounts compare. They also make it evident as students apply chunking and hopping strategies to solve addition, subtraction, multiplication, and division problems. In addition, students are able to visually comprehend alternate strategies demonstrated by their fellow classmates.

Calculators: As students plug in numbers and multiply by 10, or powers of ten, they can watch the place value move to the left. Calculators can also be used to check student work and prepare them for on-line testing. Best of all, when working as a group the calculators give additional excitement to the task.

Graphs & Gauges: Numbers used in social studies and science graphs illustrate the quantity of a population, species, etc. Measuring tools, such as rulers, measuring tape, thermometers, gauges, balance scales, measuring cups and spoons can be used to measure tangible objects or liquids.

Money: To count and calculate amounts of money by using coins and dollar bills is a definite life skill. When multiplying by 10s, the students really get excited!

Interactive Smart lessons: These lessons are engaging and make learning fun! Students can play in Technicolor! The whole class can contribute, and be involved! There are numerous smart lessons and websites that make learning interactive.

Video: Video-based sites such as, Brainpop.com, Teacher Tube, Discovery Channel all have a variety of videos that appeal to the visual learners.

Lesson #1:

Step 3: 'Carry out the Plan' 1:3

Enduring Understanding: The value of a digit in our number system is determined by the place value position. Example: The position of a digit in a number determines its value.

Essential question: How does place value determine the value of a digit?

Vocabulary: Place value, ones, tens, hundreds, thousands, millions, billions, tenths, hundredths, periods, multiple, expanded notation, standard form, compose, decompose.

The objective of the first lesson is to address the Common Core Domain: Number and Operations in Base Ten, in which the objective is for the students to understand the value of each position in the place value system, and be able to identify the value of one digit in relation to another.

By the 5^{th} grade, the students are able to identify and understand numbers up to one million. But do they understand the periods and how they form a pattern and how these numbers grow by powers of ten? Not completely; the majority of my students did not understand that in the beginning of the year. To ensure that they understand this pattern, the first step is to review place value and its periods, then give some challenges to stretch their reasoning and conceptual understanding.

The lesson begins with a video clip from the NASA website, entitled*, Seven Minutes of Terror.* This 5 minute video, in which NASA scientists and engineers talk and illustrate the challenges of designing and landing the "Curiosity" on Mars. The scientists describe how they had to be able to calculate precisely for the success of each sequence, or segment of its landing. At the very ending of the landing, there is a 7 minute lag time. So during the last seven minutes before landing, the scientists have to wait and hold their breath until they actually see its successful landing. Throughout the video, number equations, measurements, and a timer spins on the screen to show the complexity of the project. It's most exciting for the students to watch as they find themselves engaged with anticipation and fascination of space exploration and, of course, the numerous math applications!

To begin, reenact the video counter by pulling up a counter on the smart board. Watch the numbers increase as it runs. Pay close attention to the counter when it turns from 9 to 10, 99 – 100, 109 to 110, 119 to 120, 199 to 200, 299 to 300 and so on. Ask the students what just happened? Explain why this happened to your shoulder partner. Allow time for the students to share their thinking and illustrate it on the whiteboard for the others to see. This is an important insight and application because when they are able to verbalize why this happens and connect it to the fact that there are 9 ones, hundreds, or thousands in a place value and you add one more of its kind, there are now 10 (or x10) and it creates an additional 1 of the next place value.

Next, students are given numbers to write down (on a small white board or in their journals) and decompose a number by place value, such as 289 = 200+80+9, 2,349 = 2,000+300+40+9, and 135,899 = 100,000+30,000+5,000+800+90+9. Now, let's add one more to the number. How will that change it? The students will see the 9 become a 10, 99 become 100, and so on. The students will now take a turn. Each one of them has made number cards 0-9. They will work with a partner and have the opportunity to make a number. The only catch is that it must contain a 9 as the last digit. As they work with their partner, one of them will make the number and the other will record the number in one column and the number plus 1 in another. Discuss the pattern.

This will be followed up by greater challenges. Now distribute more zeros. The numbers will now have a 9 in a different place value. For example, consider 495 and add 10. Now, the number equals 505 – why? (When I taught this to my class, I thought it would be too easy, but I was wrong.) Working this type of pattern allows the students to see the meaning of the place value and how consistently the numbers work based on 10.)They are then given more sample numbers, such as 592 + 10 =, 1,924 + 100 =, 129,400 + 1,000 =. After a few trials, work with your partner again and make a number with your digit cards. The 9 digit card can be in any of the place value positions. How much will you have to add to make 10 of its kind?

You may have to do a think-aloud, for example, 2,976 + ___=3,000, there is a 9 in the hundreds place, so if I add 100 more to the number, the 900 will become 10 hundreds. Since there are now ten hundreds the 1 moves to the next place value position as one thousand. This makes sense because 10 x 100 = 1,000. So now I can say that 2,976 + 100 = 3,076.

Allow the students time to work with their partner and discover the consistent pattern and have the opportunity to verbalize or teach the other how and why the numbers are changing.

Come together and share strategies, a-ha's, questions, and real-world applications. A good example of this may be, "Look at this sale paper……what number do you see

repeatedly? …..yes there are lots of 9's…Why do you think?" Which is more $1.99 or $2.00, $19.99 or $20.00? For homework, ask the students to find a sale paper and circle the 9's in the prices. This will give them real-world application.

Variations, differentiations, and extensions to follow up this lesson:

Add interactive manipulatives. Similar lessons can be done on a number line, with base ten pieces, money (only base ten), calculators, interactive smart board manipulatives, and student drama.

Partner time: Partner A is the narrator of the NASA video and tells Partner B the distance Curiosity from Mars as it approaches for landing. The other partner must listen and write down the number.

Look in atlases, or books that you can borrow from your library, and find numbers that show numbers in the thousands, millions, billions! Students should record the numbers on a small poster paper. Ask them to label the page it appeared on, what it represents, and why it's so impressive! Allow the students to share.

The process can be reversed. They are given decomposed numbers and asked to recompose them. As these problems are being given, the students are also reading the numbers aloud chorally and/or with a partner. The students are then given some of the numbers that they saw in the Curiosity landing video. Now ask them to increase one of the place values in that number.

Comments from our Curriculum Connections:

This concept can be further explored, by connecting it with other content areas. For example, we studied immigration and were amazed at how many people survived the journey and found a home and work in New York City! This gave us the opportunity to apply our appreciation and understanding of just how many people arrived during specific time periods and overall. The students were able to use their addition and subtraction strategies with their expanded place value understanding.

In addition, in our writing unit, each student identified what kind of professional they would like to be in the future. Then, they researched the profession and explored what subjects they would need to be proficient and successful. They all came to the realization that math was everywhere! By understanding place value, whether it be counting money, stock values, medical dosages, chemistry or cooking recipes, it definitely would have a direct connection to their personal and professional success! To add to the excitement, the students researched their profession's salary. Now they had some motivation and got excited about understanding place value!

As a result of this activity, when we proceeded through the lessons, I could personally connect with the students according to their future goals. They were also eager to get to work when I asked them to create word problems accordingly to their interest! All of these activities enhanced and enriched their understanding of the math objective; that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.

Lesson #2:

Step 3: 'Carry out the Plan' 2:3

Enduring Understanding: Place value patterns continue through to decimal numbers. Example: The groupings of 1s, 10s, 100s, and 1,000s for a given number can be taken apart in different ways.

Essential Question: How can the knowledge of place value help with multiplication and division of large numbers?

Vocabulary: Multiple, factors, dividend, quotient, fraction, powers of ten

In second lesson, the students will apply their understanding of place value and to discover patterns as they solve multiplication and division problems beginning with a 10 minute video, called Power of Ten. It begins by showing a couple having a picnic in the park on a sunny day. Then the camera starts to zoom out. Although this was filmed in 1977, the students could appreciate the zooming effect immediately. A measuring counter in the corner of the screen spins and increases as it shows the scene further and further away. I recommend stopping intermittently to look at the counter and discuss the increase of distance on the counter. Soon the video was showing a picture as though you are outside the galaxy. Then it zooms back to the park, zooming even closer onto the skin of the person sitting on the grass. Now the zoom is more micro in nature. The students will be amazed to see the cells and microbes that are not visible to the naked eye! Wow! The power of ten! Now, discuss the applications and power of the microscope and the power of the telescope!

To follow up the video, ask the students to solve and look for patterns in these problems: 1 x 10 =10, 10 x 10 = 100, 100 x 10 = 1000, 1000 x 10 = 10,000, 10,000 x 10 = 100,000.

More than likely, they'll say something like, "you just add a zero…" Therein lays the problem. Sometimes it's just procedural knowledge. The challenge is to really understand it conceptually which sometimes takes more than one lesson.

For this lesson, after watching the video, demonstrate with either snapping cubes, base ten pieces, or the interactive smart board manipulatives. Model how ten singles become a ten, ten x a ten equals one hundred, 10 hundreds equals one thousand. This pattern should be looked at and discussed with other numbers to see connections similar patterns. Such as: 3 x 10 = 30, 3 x 100 = 3 x 10 x 10 = 300, so 30 x 10 = also = 300. This is an A-ha that is tricky because when the numbers increase in complexity the students need to understand it conceptually. For example, a common misunderstanding is that 50 x 80 = 40, or 8 x 500 = 400. At this point, the students must be able to look at the problem and break down the 500 it to 8 x (5 x 100) = (8 x 5) x 100 = 40 x 100 = 4000.

Seeing these patterns through a "Math Talks lesson" is very helpful. Ask the students to solve a number of problems that scaffold on the patterns mentioned above. Discuss the strategies they used. Then find connections and efficiencies. Does the procedural trick make sense now? Are there any exceptions? Any situations where it won't work or where do you need to be careful (like the situation mentioned in the previous paragraph)? Have you used this before? How? Where?

Dramatize: Prepare some large, chest-size, digit cards 0-9, and an extra supply of ten zeros. Ask for about three volunteers to start. Begin with a simple math problem such as 2 x 3 = ?, then the class chorally responds "6." The student with the number 6 stands before the class. Next, I ask, what does 6 x 10 =? The class chorally again answers…."60" So, now another student is given a zero and stands next to the student holding the 6. Continue this challenge until you get to six thousand or as high as your class can take it (6,000,000,000). When you reach 6,000, ask the students what 6,000/10 =? 600/10 =? 60/10=? 6, Did they see a pattern? Why are the numbers decreasing by 1/10's?

Time for real-world application: Make up a scenario of when this pattern might arise in the real-world. For example, "I am a manager in the lollipop factory. Ten lollipops are packed in each box. There are ten boxes in a crate. My customer wants 500 lollipops for the October shipment. How many crates do I send him? What if he wants 5000 lollipops? What can I do as a manager to make packaging easier for such a larger order?

At this point the students work together with a partner to create a multi-step problem based on multiples of ten. They will write out the problem, illustrate it, and solve it. After this task is complete, students will join another partner group and share their problem. Instruct them to cover up the illustration and solution and see how their new group members solve it. Then compare each other's drawings and strategies so everyone benefits.

Closure: Review the lesson and insights from the partner work. How did this challenge your thinking? What did you learn today that you could use somewhere else?

The next time you go into a store, look to see if there is someone unpacking boxes of products. Ask them: How many of those products come in a box? How many does the store usually order? How often do they get a shipment? How many do they typically sell per month, per year?

For homework, ask your students to create additional word problems, with illustrations and solutions, to share with the class the next day.

Math Classroom Comments:

My students needed a lot of practice talking with their partners and writing down their reasoning to describe why the number became larger and how many zeros were in the final answer. It took many practice sessions to completely understand the powers of the place value positions through multiplication and division, but after seeing the patterns and working through a variety of word problems, they now have a deeper conceptual understanding rather than a superficial rule of 'count up the zeros and add them to the number.'

Variations:

This lesson can be applied to the number line, base-ten pieces, interactive smart board manipulatives, National Library of Virtual Manipulatives, digit card games.

Comments from our Curriculum Connections:

In ELA when we read stories about immigrants coming to America, the students saw how they were packed onto the ships. This was very similar to their memories of studying the Pilgrims on the Mayflower. This time we estimated to the how many people were in a compartment to the nearest ten and then counted the compartments for a rough estimate of how many people could actually fit. My students were amazed at how fast we could figure it out, and how big the number of passengers became!

In Social Studies, we were studying the Bill of Rights. The students were able to make the connection between the large amounts of immigrants fleeing to our country for freedom. When my students came to realize that these people did not have the freedoms that we so much enjoy, and take for granted, they were amazed. During the fifty year period of 1870 to1920, there were approximately 26 million immigrants that came through Ellis Island to America. This portion of the unit was an eye-opener for the students in my class! The students learned about other governments, blights, religious persecution, and a promise for a better life and opportunities for their families. This gave them a much deeper appreciation for not just numbers of people, but why they came and the passion and determination for freedom and equality upon which our forefathers established our nation.

Activity #3:

Step 3: 'Carry out the Plan' 3:3

Enduring Understanding: Computational strategies with whole numbers can be applied to decimals. Ex: Estimation is a strategy for getting as close as possible to an exact answer.

Essential Question: What is the value of being able to estimate a product?

Vocabulary**:** Estimate, round, metric system, millimeters, centimeters, meters, units, decimal point, decimal, exponential, squared numbers.

This lesson has three challenges. The students are to take their knowledge of place value and its multiplication/division patterns to a new level and apply it to scaling. To review, the students have been to Mars, through space, and into the human body. Now it's time to consider something tangible and linear – like a building or a monument! Estimation will be introduced as a critical piece of the calculation phase of the problem solving process. In this next section we will be determining the height of the Empire State Building, The Statue of Liberty, and in our own back yard, a student creation, a Guinness World Record breaker…The Red Clay's Tallest Lego Tower in the World!

Challenge 1: How tall is the Empire State Building in pennies?

The first task is to predict how many pennies would be needed to build a stack of pennies to reach 5 cm. Next, pair up with a classmate. Distribute 20 pennies and a ruler to each pair of students. Now they can stack and measure. The only problem is that they don't have enough pennies to reach 5 centimeters. This will require them to calculate or scale up, i.e., 1 cm x 5. The second step is to calculate how many pennies would one need to reach one meter high (or 100 centimeters.) The third step is to use this information to calculate how many pennies would one need to stack up to reach the top of the Empire State Building in New York City, which is 443 meters high.

This activity forces the students to think about what they know and apply it. There will be some squirming and pleading for help, but try to let them work it out. Compare predictions, acknowledge their good team work and application of numbers and measurement tools and let them do the rest. After some squealing and got-its, there will be natural sharing and excitement of conquering the challenge. Always remember to come together and share. Make learning fun and rewarding by respecting all learners and helping those who need a hand so we can all reach the top. That should always be a priority! This is a great motivator for the class.

Challenge 2: How tall is the Statue of Liberty in pennies?

The second challenge is similar in format, but has different measurements. Begin this challenge by first previewing the Statue of Liberty. Take an exciting virtual tour to the website that zooms in and around the Statue of Liberty. See all of the measurements and cross-sections of Lady Liberty and how proudly she stands in New York Harbor!

Now the work! With sharpened pencils, students partner up once again. You can be the judge of your class as to whether or not they should have assigned partners. This time they have to predict how many pennies one would need to build a stack of pennies with the height of eight centimeters. As before, they do not have enough pennies to reach eight centimeters. (Most of my students calculated up to 2 centimeters and then multiplied that number by four.) Then, ask them to extend their thinking and calculate how many pennies would be required to reach ½ meter (50 centimeters.) This question would require them to add 2 centimeters more onto the 8 centimeter and multiply times 5.

Now, the final challenge: How many pennies would it take to reach the top of the Statue of Liberty in New York City Harbor - from the pedestal to the torch which is about 93 meters tall? Wow! Hmmm … yes they were able to work with a partner. But they also had to estimate first. As you can see the challenge reads that the Statue of Liberty was about 93 meters tall. Throughout this challenge, I encourage individual work and then share, the opposite of the previous task with the Empire State Building. Their confidence level should be rising, but they need to know that there's always help or a safety net close by.

For early finishers, I recommend that they draw another building on the back of the paper. Assign it a measurement of meters high/tall and recalculate the amount of pennies needed to reach the top! The class assignment is to take the challenge home and teach their parents. Give them the challenge, and watch what they do and then share strategies. Remember, 95% of what we learn is what we teach!

Challenge 3: How tall is the Tallest Lego Tower in the World in pennies?

For the final summative task, Google; Red Clay School District breaks the Guinness Book of Records for building the Tallest Lego Tower in the World! View with your class pictures and video of the erection of the Lego Tower on August 21, 2013 with Dr. Dougherty placing the red school house on the very top!

Now for the final challenge: This time the students work on their own. First, they are to predict how many pennies it would take to stack up to 10 centimeters high. (Hopefully, they use what they already found out from the previous activities.) Next, calculate how many it would take to stack 1 meter high. Then, complete the challenge: The World's

Tallest LEGO Tower was built by students of the Red Clay School District in Wilmington, DE, on August 21, 2013. It stood 112ft, ¾ inches tall! This is the same as10 stories or 34.44 meters high! How many pennies would one need to stack up to reach the top?

After students calculate their answer, ask them to express it in expanded form and exponential form. As you can see, I added distractors into the problem. The students would have to think about which measurement they would use – stories high, feet and inches, or meters?

Math Class Comments:

By carefully scaffolding the thinking process of these three challenges with small steps and plenty of opportunities for positive reinforcement, partner work, exploration, and cross-curriculum applications, my students did amazingly well! I'm sure yours will too! My hope is that if you try this series of challenges that you integrate it with the other subjects in your curriculum, your students' interests, and most of all make it fun and real. Personally, I would like to continue this to an actual building stage. Perhaps it can be tied into the fractions unit. Besides, fractions are everywhere too!

Comments from our Curriculum Connection:

ELA: The Reading unit theme is all about how to handle and deal with challenges in life. So, as we worked on these challenges, we connected back to story characters, fables, athletes, and personal heroes. Students analyzed the characters traits to decide what traits they had that made them successful? What obstacles did they have to overcome? Where did they get their strength? How did they make good decisions? All of these stories lent themselves to life's lessons that encourage positive thinking, strength, determination, passion, perseverance, honesty, humility, and respect.

Writing: The students also researched and wrote a biography about a personal hero. They presented their essay to the class and concluded with how they would or could apply the lessons that they learned from their personal hero to their personal life.

Social Studies: We continued discussing the legendary heroes of the past, the authors of the Constitution and the Bill of Rights.

KiVA: Anti-Bullying Program. The lessons covered during this unit were about being kind and displaying appropriate behavior to others and how to address those who are bothering you. The opportunity to discuss these matters in class has allowed personal reflection and growth time for each of the students. I think it also contributed to the harmony in our work groups as well.

Conclusion

Step 4: 'Verify Learning'

This is a final research project. The students will pick one of the endangered species, and research the following:

Describe its habitat (ecosystem)
Past and present population (include data)
Present issues that threaten their survival (injustice to the innocent? include data)
What is being done (new laws/acts?)
Do you think it is working (include data) or does something else need to be done?

This project will allow students to apply their knowledge from all of their content areas: Reading Theme – the students have just completed a unit in reading which was based on the theme of having 'the freedom to do the right thing.' Many heartfelt discussions have been a result of digging deeply into the story meanings and messages for the greater good. Reading skills covered were fact and opinion, fact and fiction, viewpoint, sequencing, and compare and contrast.

Science - The students are also creating a biome in science, so they are thinking about the food web and balance in nature. By looking at habitat conditions we can understand why some animals remain in their habitat all year long, while others migrate. The students are also thinking about natural disasters and how they affect the natural balance of nature. This brings us to un-natural threats, those from mankind; whether if they be chemically introduced, loss of natural resources, or over-hunting for personal gain.

Social Studies – Due process, Bill of Rights, Immigration all lead to discussion of making good choices, respecting freedom and being responsible. Also, students have gained an appreciation for the great number of people who immigrated to our country and those who never made it and lost their lives due to unjust treatment.

All of these content areas will combine with the math base ten concepts which will shed some proof and reality on the global issues of today. As the students continue to realize that they are our future, they are showing a very keen interest in finding out more about what has been done, what kind of work still needs to get done, and how can they be authors of their future.

Appendix A Common Core State Standards & Math Practices

CC.5.NBT.1 – Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left. This standard is addressed in the first activity or phase of the unit where the students work to understand the meaning and significance of place value system's

‘big’ numbers. As they study and compare quantity of numbers in space, distance, money, etc., they will recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.

CC.5.NBT.2 – Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use positive integer exponents to denote powers of 10. This standard is addressed in the second activity or phase of the unit where the students view the video, Powers of Ten, where the power of ten is truly demonstrated. They will then use multiplication and division to further to work with the patterns and gain deeper understanding of the significance of the meaning of a number.

CCSS.Math.Content.5.NBT.A.4 Use place value understanding to round decimals to any place. The third lesson will teach them to use place value understanding to round numbers to the nearest place value position. This is a critical skill when working with larger numbers. By strengthening this skill the students will increase their ability to do mental math and decompose numbers more fluently as they solve increasingly complex problems. This form of estimation will be also incorporated into the calculation phase of the problem solving process.

CC.5.NBT.5 – Fluently multiply multi-digit whole numbers using the standard algorithm. CC.5.NF.5 – "Interpret multiplication as scaling (resizing) by comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication. These standards are also addressed in the third activity or phase of the unit when the students will predict, measure using centimeters, convert to meters (x100), and then apply this knowledge to a three digit number of meters to which they will be required to round and calculate the total length. After which, the students will calculate the exact number, then transpose the total to expanded notation, and finally express the same number as a number sentence using exponential expressions.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Appendix B

Name: _____ Date: _____

The Great Red Clay Lego Tower

Each group will receive 20 pennies.
You may use any of the tools in the classroom, including graph paper and a ruler.

1 A. Predict how many pennies you will need to build a stack 10 cm. high?

_____

B. Check your prediction. How many pennies did you need?

_____

C. How accurate was your prediction? Explain your answer.

_____

2. How many pennies would you need to build a stack 1 meter high? (100 cm. = 1meter)

Explain how you found your answer.

3. The World's Tallest LEGO Tower was built by Students of the Red Clay School District in Wilmington, DE, on August 21, 2013. It stood 112ft, ¾ inches tall! This equals 10 stories or 34.44 meters high!

How many pennies would you need to build a stack to reach the top of the Lego Tower?

A. Calculate using estimation.

B. Calculate using precise numbers.

C. Show your work. Please draw a diagram of the tower, label, and use number sentences to explain your answer. (Use the back of the paper or another piece of paper to show your work for this challenge.)

D. Rewrite you answer in both:

1.) Expanded Notation

_____

2.) Exponential Notation

_____

Teacher Video Resources

NASA: Seven Minutes of Terror – http://www.jpl.nasa.gov/video/index.php?id=1090
Powers of Ten – http://www.youtube.com/watch?v=0fKBhvDjuy0
Statue of Liberty – http://www.youtube.com/watch?v=42yO2FUWL6A
http://www.bing.com/videos/search?q=ststue+of+Liberty&qpvt=ststue+of+Liberty&FORM=VQFRML#view=detail&mid=4E71BFB077F6C28D10F74E71BFB077F6C28D10F7
Empire State Building -
http://www.bing.com/videos/search?q=Empire+State+Building+History&Form=VQFRVP#view=detail&mid=D372D228D99A5FD20F00D372D228D99A5FD20F00
Red Clay's Tallest Lego Tower in the
World http://www.youtube.com/watch?v=XbzlfJtE16Y
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This book shows how investigating the behavior of operations advance students

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This book reviews students and their feelings about math and how it affects their performance.

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Brown, S. & Walter, M. *The Art of Problem Posing.* New York: Routledge, 2005.
This book encourages readers to shift their thinking about problem posing and extend to what can be done with problems.

Capraro, M., R. & Morgan, J. *STEM Project-Based Learning*, Rotterdam, Sense Publishers, 2013.
STEM PBL is a just in time sequential resource for educators as they begin their journey of teaching and implementing a PBL unit.

Dweck, Carol S. *Mindset, The new Psychology of Success.* New York: Random House Publishing Group, 2006.
Carol Dweck talks about the power of a growth mindset versus a fixed mindset and how educators can influence student thinking and success.

Gregory, G. & Chapman, C. *Differentiated Instructional Strategies.* Thousand Oaks, Corwin Press, 2007.

This book is full of research-based practices in pedagogy and assessments for learning.

Hollas, Betty. "Differentiating Instruction in a Whole Group Setting", Petersborough, Crystal Springs Books, 2005.

This book reviews the latest research and activities that are effectively increase engagement in the classroom.

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Parrish, Sherry. *Number Talks.* Sausalito, CA: Math Solutions, 2010.

Poyla, G. *How to Solve It, a new aspect of mathematical method.* Princeton Science Library, 2004.

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Thurston, W. "Mathematical Education." In *Mathematical Education*, by Thurston W., Notices of the AMS, 1990.

Xiangyun Du, Erik de Graff, Anette Kolmos. *Research on PBL Practice in Engineering Education.* Rotterdam, Netherlands: Sense Publishers, 2009.

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Notes

[1] Xiangyun Du, Erik de Graff, Anette Kolmos. *Research on PBL Practice in Engineering Education.* (Rotterdam, Netherlands: Sense Publishers, 2009), 11.

[2] *K–8 Publishers' Criteria for the Common Core State Standards for Mathematics,* Spring 2013 Release, 04/09/2013, http://www.corestandards.org/resources.

[3] Betty Hollas, Differentiating Instruction in a Whole Group Setting, (Petersborough, Crystal Springs Books, 2005),14-15.

[4] George Poyla, *How to Solve It, a new aspect of mathematical method.* (Princeton, Princeton Science Library, 2004),6-8.

[5] Diana Lambdin, "Benefits of Teaching through Problem Solving." in *Teaching Mathematics through Problem Solving*, Ed. Frank Lester, (Reston,Virginia: National Council of Teachers of Mathematics, 2006) 6-12.

[6] Poyla, introduction, xvi-xvii.

[7] Carol S. Dweck, *Mindset, The new Psychology of Success.* (New York: Random House Publishing Group, 2006),39-54.

[8] Erna Yackel, "*Listening to Children: Informing Us and Guiding Our Instruction."* in *Teaching Mathematics Through Problem Solving*, Ed. Frank Lester, (Indiana University of Bloomington, National Council of Teachers of Mathematics, 2003) 117.

[9] Xiangyun Du, Erik de Graff, Anette Kolmos. *Research on PBL Practice in Engineering Education.* (Rotterdam, Netherlands: Sense Publishers, 2009), 35-42.

[10] Oliver Knill, "Harvard Calcuclus Consortium." *Harvard Calcuclus Consortium*, 2009: http://www.math.harvard.edu/~knill/pedagogy/harvardcalculus/.

[11] Sherry Parrish, *Number Talks.* (Sausalito, Math Solutions, 2010), 3-29.

[12] Erna Yackel, "Listening to Children," 121.

Curriculum Unit Title	Why Does Place Value Matter?	Author	Sonia D. Saunders

KEY LEARNING, ENDURING UNDERSTANDING, ETC.

- The position of a digit in a number determines its value.
- The groupings of 1s, 10s, 100s,1nd 1000s for a given number can be taken apart in different ways.
- Estimation is a strategy for getting close as possible to an exact number.

ESSENTIAL QUESTION(S) for the UNIT

- How does place value determine the value of a digit?
- How can the knowledge of place value help with multiplication and division of a large number?
- What is the value of being able to estimate a product?

CONCEPT A	CONCEPT B	CONCEPT C
The value of the digit in our number system is determined by the place value position.	Place value patterns continue to decimal numbers .	Computational strategies with whole numbers can be applied to decimals.
ESSENTIAL QUESTIONS A	**ESSENTIAL QUESTIONS B**	**ESSENTIAL QUESTIONS C**
How does place value determine the value of a digit?	How can the knowledge of place value help with multiplication and division of large numbers?	What is the value of being able to estimate a product?
VOCABULARY A	**VOCABULARY A**	**VOCABULARY A**
place value, ones, tens, hundreds, thousands, billions, tenths, hundredths,periods,multiple, expanded notation, compose, decompose	multiple, factors, dividend, quotient, fraction, exponent, squared	estimate, round, metric system, meters centimeters, units, decimal point, decimal, fraction

ADDITIONAL INFORMATION/MATERIAL/TEXT/FILM/RESOURCES

NASA: Seven Minutes of Terror – http://www.jpl.nasa.gov/video/index.php?id=1090
Powers of Ten – http://www.youtube.com/watch?v=0fKBhvDjuy0
Statue of Liberty
http://www.bing.com/videos/search?q=ststue+of+Liberty&qpvt=ststue+of+Liberty&FORM=VQFRML#view=detail&mid=4E71BFB077F6C28D10F74E71BFB077F6C28D10F7
Empire State Building - http://www.bing.com/videos/search?q=Empire+State+Building+History&Form=VQFRVP#view=detail&mid=D372D228D99A5FD20F00D372D228D99A5FD20F00
Red Clay's Tallest Lego Tower in the World http://www.youtube.com/watch?v=XbzlfJtE16Y
Brain Pop - http://www.brainpop.com/math/