V. 4. THE CORE PROCESSES OF MATHEMATICS pdf

1: Common Core / Homepage

California Math Triumphs The Core Processes of Mathematics, Volume 4A November 5, 2-Pdf embed, Macmillan, Maths, Others, Primary school No Comments Related Posts.

Hyper-V is a full hypervisor in spite of the fact that it looks like Windows at the console and therefore it operates just like hypervisors have for the past 10 years. When dealing with hypervisors it is easier to think in cores and virtual processors than it is to think in cores, logical processors, and virtual processors. In reality what really matters is cores and virtual processors. Each core very safely support 8 virtual processors. Can you go beyond this number? The thing to plan for when moving to virtual machines is to plan hypervisor capacity in a scale-out type of way. Thus the overloaded hypervisor re-balances and your new one picks up some work. So, you need to plan in the flexibility to move VMs either with Live Migration or by powering them off between hypervisors to balance the work. Managing hypervisors and VM workloads is still an art, not a science - as there are so many variables that affect the workload, the VM OS, the hypervisor, and the hardware. In the end you will be far more productive with two hypervisors than you would be with one huge one. So, if vCPU is not equal to logical processor, can you explain why there is difference in the performance of task manager? So, one vCPU is equal to one core? From this link http: Microsoft recommends that you maintain a one-to-one ratio of virtual processors to physical CPU cores. On top of that, I recommend that you reserve at least one CPU core for the host operating system. This means that if you stick to the recommendation, a server with four CPU cores could host up to three virtual machines, with one virtual processor each because one cores being used by the host operating system. You can also host two virtual machines, one with two virtual processors in one with one virtual processor. This is a case where you need to know your hardware. Thanks for including the Petri link. I see the MSFT recommendation being over-generalized here. The Petri article statement of: The most common things I have seen are: Now, let me get really technical on you.. That single VM will technically share in the processing resources of all of the cores watch my video about this. The parent partition is the only element that is parked on core 0. Virtual processors are all about time, and the amount of time spent on the CPU and the amount of time not spent on the CPU. Again, I discuss this and visually represent this in my video. In the case of hypervisors a Logical processor does equal a vCPU. However, a logical processor does not equal a core, nor does Task Manager show you the number of Logical Processors that you have. Ben the Hyper-V PM describes it this way: This is a single execution pipeline on the physical processor. In the "good old days" someone could tell you that they had a two processor system - and you knew exactly what they had. Today if someone told you that they had a two processor system you do not know how many cores each processor has, or if hyper threading is present. A two processor computer with hyper threading would actually have 4 execution pipelines - or 4 logical processors. A two processor computer with quad-core processors would in turn have 8 logical processors. What is different between logical processor and a physical processor? On what parameters it depends i. Above BrianEh mentioned that: Prior to this we had hyper threading. Sockets are the number of processor sockets that your motherboard has. And, sockets are only potential. What we really care about is the number of processors that are installed, as a socket could be empty. A motherboard with 2 sockets can support 2 processors. The number 8 that used is the recommended calculation for capacity planning circa - 8 virtual processors per core. A common 1U server might be: As it all depends on how your VMs are configured as each decrement from this total of Now, the fun hitch to all of this - these are guidelines. And they can all run at the same time too. The statistics are good; however, that you will run out of RAM or hit diminishing returns with disk IO before your host will run out of processing capacity for virtual machines. Physical to virtual calculation Q: Can I allocate these 32 CPUs to one virtual machine? And what will happen I want to add some other Virtual Machines? This is because CPU time is a finite resource and all VMs must share nicely in using that finite resource. Your statement of "Logical Processors: If I work your configuration backward Hyper-V then divides these 8 physical into 8 logical processors which is also referred to as a vCPU for a total of 64 virtual processors. I understand that the virtual cores are basically an allocation of time to the entire 8 cores? I just have a software developer telling me that his software will only use 4 cores if presented with the 4 virtual CPU. I said yes it will seem that way to the OS, but under that it will be actually using all 8 cores as the load is spread across them all. Am i correct in that assumption? A physical core gets divided into 8 vCPUs these are technically logical processors and therefore represent processing time on the physical stack with a maximum of 8 concurrent threads executing on a physical processor at any one moment in time. The result is that the execution never has a breakpoint and therefore the hypervisor never gets a chance to cycle the work to the next processor.

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2: Standards for Mathematical Practice | Common Core State Standards Initiative

The Common Core standards are not curriculum. Curriculum is what teachers actually follow, or do, in the classroom, and what students do at home. Standards simply say what we want students to learn.

MP1 Make sense of problems and persevere in solving them. Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, "Does this make sense? MP2 Reason abstractly and quantitatively. Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects. MP3 Construct viable arguments and critique the reasoning of others. Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, andâ€”if there is a flaw in an argumentâ€”explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments. MP4 Model with mathematics. Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose. MP5 Use appropriate tools strategically. Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts. MP6 Attend to precision. Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions. MP7 Look for and make use of structure. Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see 5 - 3 x - y 2 as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y. MP8 Look for and express regularity in repeated reasoning. Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results. Connecting the Standards for Mathematical Practice to the Standards for Mathematical Content The Standards for Mathematical Practice describe ways in which developing student practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle and high school years. Designers of curricula, assessments, and professional development should all attend to the need to connect the mathematical practices to mathematical content in mathematics instruction. The Standards for Mathematical Content are a balanced combination of procedure and understanding. Expectations that begin with the word "understand" are often especially good opportunities to connect the practices to the content. Students who lack understanding of a topic may rely on procedures too heavily. Without a flexible base from which to work, they may be less likely to consider analogous problems, represent problems coherently, justify conclusions, apply the mathematics to practical situations, use technology mindfully to work with the mathematics, explain the mathematics accurately to other students, step back for an overview, or deviate from a known procedure to find a shortcut. In short, a lack of understanding effectively prevents a student from engaging in the mathematical practices. In this respect, those content standards which set an expectation of understanding are potential "points of intersection" between the Standards for Mathematical Content and the Standards for Mathematical Practice. These points of intersection are intended to be weighted toward central and generative concepts in the school mathematics curriculum that most merit the time, resources, innovative energies, and focus necessary to qualitatively improve the curriculum, instruction, assessment, professional development, and student achievement in mathematics.

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3: Further Mathematics - Wikipedia

These practices rest on important "processes and proficiencies" with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections.

To date, 43 states have adopted these standards, which aim to better prepare students from kindergarten through 12th grade for higher education and career success. And based on that talk, it seems that people think everything is new about these standards. The truth is, while some aspects are new, many are not. Indeed, there is a greater focus on these core topics than was typical of state standards before the Common Core. This brings us to what IS new. To put it simply: Teachers and parents have been aiming for this for years. Now teachers and parents are supported by standards that lay out clear and coherent trajectories toward building a better understanding of mathematics, so children are less likely to lose their skills after graduation. This traditional method is still required by Common Core. Knowledge not supported by understanding is fragile. Today, through the standards, kids learn mental strategies for addition and subtraction that help them use the standard algorithm with common sense about how those operations work. Mental strategies based on understanding make procedural knowledge flexible, applicable to other disciplines and situations. Teaching at the university level, I see the consequences of learning mathematics without understanding all the time. Students whose knowledge of algebra is based on a million meaningless mnemonics often crumble when faced with problems posed in an unconventional way or using unconventional notation, as they inevitably will be in their classes in a wide variety of subjects. The students who do well understand that the letters in their equations are just numbers, and that the things they can do with equations follow the same arithmetical properties they learned in elementary school. The Common Core standards explicitly focus on those properties in order to prepare students for success in college. So, what do you as a parent need to know about the Common Core? Here are three things to remember: The Common Core standards are not curriculum. Curriculum is what teachers actually follow, or do, in the classroom, and what students do at home. Standards simply say what we want students to learn. Common Core establishes a set of goals for learning. But without good curriculum, the standards are just that: You can also expect your child to be able to explain how she knows what she knows, show how she thought about an answer, and choose different strategies for different problems. The math problems that you remember are still important. The Common Core standards are both old and new. For more information about the Common Core standards, visit CoreStandards. And check out these links for additional information:

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4: California Math Triumphs The Core Processes of Mathematics, Volume 4A

Free The Problems with the Common Core. Authored By Stan Karp. The rollout of the Common Core has seemed more like a marketing campaign than an educational plan. A look at the funders, origins, and uses of the new standards shows why the pushback is building.

Teachers, administrators, and others on the committee should translate what is called for in national, state, and local standards into administrative and classroom policy and practice for their district. The committee will want to consult research literature and other sources on best practices in teaching and learning science and mathematics. A common vision helps focus all stakeholders on what the school district believes is important. The vision is critical for good communication, as it will help the committee describe what the practices and behaviors of students, teachers, administrators, and parents should be when the curriculum program is in place. In building a common vision, the design committee should describe what would be observable when the curriculum program is fully developed and implemented in terms of what students are learning and how they are learning it; what teachers are doing to support, encourage, and expect learning; the evidence to be used during assessment of student performance; and activities parents, administrators, businesses, and colleges and universities are engaged in to support and encourage high levels of student performance. One such discussion might include tracing the development of a particular concept or strand across several grade levels, and correlating this development with national and state standards documents. Examining sample instructional materials or student work also could help the committee clarify the nature of student Page 34 Share Cite Suggested Citation: Designing Mathematics or Science Curriculum Programs: The National Academies Press. Classroom examples paint pictures that communicate to teachers, administrators, supervisors, and members of the public how students engage in meaningful learning of mathematics or science. The classroom examples in the NSES have helped educators get a concrete sense of the national recommendations in practice. In addition, committee members may want to participate in actual classroom lessons, either as teachers or as students. It is important at this stage in the development of a curriculum program for the committee members to have an opportunity to share and discuss their many, often diverse, views about the discipline itself mathematics or science and about how students learn that discipline. For example, teachers may not agree about the contributions and limitations of lecture versus inquiry or of small group versus large group instruction. These issues are best addressed explicitly in a positive, professional environment where relevant educational research literature can be accessed and reviewed. It should illustrate how standards will be used and describe what a classroom should look like or what kind s of thinking a student should be able to do. This framework is meant to organize and sequence the content to create coherence in the curriculum program across all grades in all courses. It does this by assigning concepts to grade levels based on the growth and development of ideas and skills from grade to grade and by grouping the concepts to form units or courses. Whether the framework is developed locally or taken from an outside source, it should be reviewed carefully to ensure its coherence. Page 35 Share Cite Suggested Citation: Therefore, drafting a framework is the beginning of an iterative process. First, a draft of the framework indicates at which grade level concepts and skills these may be expressed as standards or benchmarks, depending on the document being used might be taught. Then, as instructional materials are reviewed, this early framework will be refined until a final product emerges. If districts assign concepts to grade levels or courses before looking at instructional materials, they are likely to create a need for unique units or courses. This then places them in the position of having to write materials â€” a difficult and expensive process that most districts do not have the resources to accomplish. The design committee should have the following questions in mind while drafting the framework: Are some units so ingrained in the local curriculum that they must be retained? If this is the case, the appropriate standards must be referenced in the framework. Who are the intended audiences of the framework? How will these audiences use the framework? Will they understand it in its current form? What instructional resources are available locally in the community that should be built into the framework? For example, an outdoor education laboratory school, a district greenhouse or planetarium, a museum of science and industry, or connections with a local industry may all complement a high-quality curriculum program. The goal of this step is to identify instructional materials that best support the standards as they are organized in the draft curriculum framework. As men 10 Because of the widespread influence of national standards in mathematics and science, increasing numbers of instructional materials and, in some cases, multi-year programs are available commercially that provide for instruction and the learning of content called for in the national standards. Both commercial publishers and curriculum development groups funded by the National Science Foundation have developed these materials. Some of the programs may address a number of the criteria for curriculum programs outlined above; therefore, local design process committees may use some aspects of these programs â€” as well as adjustments to their own local frameworks â€” to help them construct coherence within and across grades. Page 36 Share Cite Suggested Citation: The draft framework indicates a possible assignment of standards to grade levels. Examining the instructional materials informs the committee as to what is available at each grade level, how the standards are presented in the materials, and the prior knowledge students need before beginning each unit. After the design committee reviews information about the materials, it may find a need to revise some portions of the framework. Committee members should be selective about their review of material because they will not have time to review everything. Department of Education all are working to analyze and identify or to help local decision makers analyze and identify exemplary mathematics or science materials NRC, c; AAAS, ; and DoEd, The design committee may want to consider reviewing the materials currently in use. Even though some members will be familiar with these materials, all materials that have the potential for use in the curriculum program should be reviewed using the same set of criteria. Then, if there is a decision to drop a widely used textbook, evidence will be available. Conversely, if a district chooses to continue using a program that is unpopular, how and why this decision was made may be more easily explained. Review Instruments and Procedures. With the introduction of content standards, most districts will need to revise their process for reviewing instructional materials, employing criteria similar to those outlined in the second section of this report. The review process should be clearly defined and involve the use of multiple techniques that give teachers and others an opportunity to analyze the materials under consideration. Supplemental materials may play a role in this process and will be discussed later in this section beginning on pg. A considerable amount of time is needed for careful review of materials. In this first stage, the committee also could exclude materials that are collections of unrelated activities or short units on single topics not connected to others. This would allow members to focus in the second stage on materials that have the most potential to support the development of a coherent curriculum program. In the second stage, reviewers need to begin by choosing a review instrument and then practicing with it. In the practice session, all reviewers should use the instrument to evaluate the same set of instructional materials. The reviewers should discuss and agree as a group on the interpretation of each criterion to increase the reliability of the resulting reviews i. Working through this process also will give reviewers further insight into the standards that they will be using to judge the materials. The results of the first and second stages of review should reveal strengths and weaknesses of each considered set of materials. The next step is to use this knowledge to refine the framework. The design committee, having worked with the policy documents goals and standards , developed and described its vision of teaching and learning, analyzed the current program, and reviewed and selected instructional materials, is ready to begin refining the curriculum framework. Refining the framework involves 1 clarifying the growth of student understanding within and across years by assigning concepts to grade levels, and 2 identifying and addressing transitions and gaps in the framework, as follows: Clarifying the growth of student understanding within and across years by assigning concepts to grade levels. Once instructional materials have been selected, concepts and skills can be assigned to grade levels. Page 38 Share Cite Suggested Citation: For example, a topic such as "introduction to photosynthesis" may be assigned to sixth grade. As written, this phrase can be interpreted in many ways. Some teachers may have their sixth-grade students memorize definitions; other teachers may go so far as to have students design experiments to collect evidence that plants need light; and yet others will ask students to memorize the equations that summarize the chemical reaction. In mathematics, a similar situation arises when a topic such as "length" is assigned to the first grade. Some teachers may feel that they should help students understand the concept of measuring length by using non-standard units; others may use standard units, such as centimeters or inches but not tools such as rulers and meter sticks; and yet others may go directly to measuring with rulers and meter sticks. As discussed in the previous section on curriculum program components, the most significant difference among frameworks is their level of coherence. To build coherence into a framework requires clear descriptions of the content. Necessary prior knowledge is identified, ideas sequenced, and connections among ideas developed. This process is facilitated by using "Growth of Understanding" tables similar to Figures 4 and 5 on pgs. Such a progression helps insure that students will be able to develop a solid understanding of the "big ideas" of the discipline. Although this progression has to be considered for each major concept, skill, and ability, every concept should not be addressed every year. This would result in too many concepts being addressed each year without adequate time for students to develop an understanding of anything, exacerbating the problem described in TIMSS reports Schmidt et al. Typical mathematics and science curricula attempt to address far too many topics per grade level. Unnecessary repetition can quickly stifle both student enthusiasm and understanding, leading to low expectations. One of the most important lessons from international studies and analyses cited in the introduction to this report is the value of tightening the focus of our curriculum to address fewer topics each year, allowing for much greater depth of learning. Ideas also must build within a year. Attention must be paid to the development of themes, concepts, and skills from the beginning to the end of a school year. The framework should be explicit about how skills and concepts interweave within individual units, across a year, and over a span of years. Without this purposeful interconnection, the curriculum program cannot be coherent. To illustrate, in science students too often read about a rigid "scientific method" at the beginning of the school year, then they read science content for the rest of the year without ever having the opportunity to experience how science concepts are derived from investigations. In mathematics, a parallel experience often occurs, when algorithmic procedures are taught as though they were important in and of themselves, rather than as tools for solving real-world problems. In such cases, the understanding that is essential to the eventual application of the algorithms is often omitted. Equally efficient procedures that are better understood â€” or that have been created by students â€” may be equally as acceptable and never considered. Even when efforts are made to address standards, concepts and skills often are separated. Students may study independent units on graphing, metric measurement, and microscope use or on plant classification, plant structure, and plant distribution, without ever seeing the connections among the concepts and skills in those units. The following questions can guide the development of a framework that supports a logical and sequential building of student understanding: What prior knowledge is needed for each concept? Is it addressed in an earlier unit? Can it be presented in the current unit? Is a logical or developmental sequence of concepts presented within each grade level? How will we assist students who have missed important prior knowledge and experiences? How does the framework convey the importance of interconnected skills and concepts? How will the connections and prior knowledge and skills called for in the framework be conveyed to teachers and others who are using the curriculum program? Identifying and addressing transitions and "gaps" in the framework.

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5: Meeting Standards with EM - Everyday Mathematics

The Common Core State Standards (CCSS) are a set of academic standards in mathematics and English language arts/literacy (ELA) developed under the direction of the Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA).

For roughly the first half of the century, success in learning the mathematics of pre-kindergarten to eighth grade usually meant facility in using the computational procedures of arithmetic, with many educators emphasizing the need for skilled performance and others emphasizing the need for students to learn procedures with understanding. Reactions to reform proposals stressed such features of mathematics learning as the importance of memorization, of facility in computation, and of being able to prove mathematical assertions. These various emphases have reflected different goals for school mathematics held by different groups of people at different times. Our analyses of the mathematics to be learned, our reading of the research in cognitive psychology and mathematics education, our experience as learners and teachers of mathematics, and our judgment as to the mathematical knowledge, understanding, and skill people need today have led us to adopt a Page Share Cite Suggested Citation: Helping Children Learn Mathematics. The National Academies Press. Yet our various backgrounds have led us to formulate, in a way that we hope others can and will accept, the goals toward which mathematics learning should be aimed. In this chapter, we describe the kinds of cognitive changes that we want to promote in children so that they can be successful in learning mathematics. Recognizing that no term captures completely all aspects of expertise, competence, knowledge, and facility in mathematics, we have chosen mathematical proficiency to capture what we believe is necessary for anyone to learn mathematics successfully. Mathematical proficiency, as we see it, has five components, or strands: These strands are not independent; they represent different aspects of a complex whole. Each is discussed in more detail below. The most important observation we make here, one stressed throughout this report, is that the five strands are interwoven and interdependent in the development of profi ciency in mathematics see Box 4â€”1. Mathematical proficiency is not a one-dimensional trait, and it cannot be achieved by focusing on just one or two of these strands. In later chapters, we argue that helping children acquire mathematical proficiency calls for instructional programs that address all its strands. As they go from pre-kindergarten to eighth grade, all students should become increasingly proficient in mathematics. That proficiency should enable them to cope with the mathematical challenges of daily life and enable them to continue their study of mathematics in high school and beyond. The five strands are interwoven and interdependent in the development of proficiency in mathematics. The five strands provide a framework for discussing the knowledge, skills, abilities, and beliefs that constitute mathematical proficiency. At the same time, research and theory in cognitive science provide general support for the ideas contributing to these five strands. Fundamental in that work has been the central role of mental representations. How learners represent and connect pieces of knowledge is a key factor in whether they will understand it deeply and can use it in problem solving. Thus, learning with understanding is more powerful than simply memorizing because the organization improves retention, promotes fluency, and facilitates learning related material. The central notion that strands of competence must be interwoven to be useful reflects the finding that having a deep understanding requires that learners connect pieces of knowledge, and that connection in turn is a key factor in whether they can use what they know productively in solving problems. Furthermore, cognitive science studies of problem solving have documented the importance of adaptive expertise and of what is called metacognition: These ideas contribute to what we call strategic competence and adaptive reasoning. Finally, learning is also influenced by motivation, a component of productive disposition. Conceptual Understanding Conceptual understanding refers to an integrated and functional grasp of mathematical ideas. Students with conceptual understanding know more than isolated facts and methods. They understand why a mathematical idea is important and the kinds of contexts in which is it useful. They have organized their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know. Because facts and methods learned with understanding are connected, they are easier to remember and use, and they can be reconstructed when forgotten. They monitor what they remember and try to figure out whether it makes sense. They may attempt to explain the method to themselves and correct it if necessary. Students often understand before they can verbalize that understanding. Page Share Cite Suggested Citation: For example, suppose students are adding fractional quantities of different sizes, say They might draw a picture or use concrete materials of various kinds to show the addition. They might also represent the number sentence as a story. They might turn to the number line, representing each fraction by a segment and adding the fractions by joining the segments. By renaming the fractions so that they have the same denominator, the students might arrive at a common measure for the fractions, determine the sum, and see its magnitude on the number line. By operating on these different representations, students are likely to use different solution methods. This variation allows students to discuss the similarities and differences of the representations, the advantages of each, and how they must be connected if they are to yield the same answer. Connections are most useful when they link related concepts and methods in appropriate ways. Mnemonic techniques learned by rote may provide connections among ideas that make it easier to perform mathematical operations, but they also may not lead to understanding. Knowledge that has been learned with understanding provides the basis for generating new knowledge and for solving new and unfamiliar problems. They gain confidence, which then provides a base from which they can move to another level of understanding. With respect to the learning of number, when students thoroughly understand concepts and procedures such as place value and operations with single-digit numbers, they can extend these concepts and procedures to new areas. For example, students who understand place value and other multidigit number concepts are more likely than students without such understanding to invent their own procedures for multicolumn addition and to adopt correct procedures for multicolumn subtraction that others have presented to them. The same observation can be made for multiplication and division. Conceptual understanding helps students avoid many critical errors in solving problems, particularly errors of magnitude. For example, if they are multiplying 9. They might then suspect that the decimal point is incorrectly placed and check that possibility. Conceptual understanding frequently results in students having less to learn because they can see the deeper similarities between superficially unrelated situations. Their understanding has been encapsulated into compact clusters of interrelated facts and principles. If necessary, however, the cluster can be unpacked if the student needs to explain a principle, wants to reflect on a concept, or is learning new ideas. A good example of a knowledge cluster for mathematically proficient older students is the number line. In one easily visualized picture, the student can grasp relations between all the number systems described in chapter 3 , along with geometric interpretations for the operations of arithmetic. It connects arithmetic to geometry and later in schooling serves as a link to more advanced mathematics. As an example of how a knowledge cluster can make learning easier, consider the cluster students might develop for adding whole numbers. If students understand that addition is commutative e. By exploiting their knowledge of other relationships such as that between the doubles e. Because young children tend to learn the doubles fairly early, they can use them to produce closely related sums. These relations make it easier for students to learn the new addition combinations because they are generating new knowledge rather than relying on rote memorization. Conceptual understanding, therefore, is a wise investment that pays off for students in many ways. In the domain of number, procedural fluency is especially needed to support conceptual understanding of place value and the meanings of rational numbers. It also supports the analysis of similarities and differences between methods of calculating. These methods include, in addition to written procedures, mental methods for finding certain sums, differences, products, or quotients, as well as methods that use calculators, computers, or manipulative materials such as blocks, counters, or beads. Procedural fluency refers to knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately, and efficiently. They also need to know reasonably efficient and accurate ways to add, subtract, multiply, and divide multidigit numbers, both mentally and with pencil and paper. A good conceptual understanding of place value in the base system supports the development of fluency in multidigit computation. Connected with procedural fluency is knowledge of ways to estimate the result of a procedure. It is not as critical as it once was, for example, that students develop speed or efficiency in calculating with large numbers by hand, and there appears to be little value in drilling students to achieve such a goal. But many

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tasks involving mathematics in everyday life require facility with algorithms for performing computations either mentally or in writing. In addition to providing tools for computing, some algorithms are important as concepts in their own right, which again illustrates the link between conceptual understanding and procedural fluency. Students need to see that procedures can be developed that will solve entire classes of problems, not just individual problems. It is important for computational procedures to be efficient, to be used accurately, and to result in correct answers. Both accuracy and efficiency can be improved with practice, which can also help students maintain fluency. Students also need to be able to apply procedures flexibly. Not all computational situations are alike. For example, applying a standard pencil-and-paper algorithm to find the result of every multiplication problem is neither neces- Page Share Cite Suggested Citation: Students should be able to use a variety of mental strategies to multiply by 10, 20, or or any power of 10 or multiple of Also, students should be able to perform such operations as finding the sum of and 67 or the product of 4 and 26 by using quick mental strategies rather than relying on paper and pencil. Further, situations vary in their need for exact answers. Sometimes an estimate is good enough, as in calculating a tip on a bill at a restaurant. Sometimes using a calculator or computer is more appropriate than using paper and pencil, as in completing a complicated tax form. Hence, students need facility with a variety of computational tools, and they need to know how to select the appropriate tool for a given situation. Procedural fluency and conceptual understanding are often seen as competing for attention in school mathematics. But pitting skill against understanding creates a false dichotomy. Understanding makes learning skills easier, less susceptible to common errors, and less prone to forgetting. By the same token, a certain level of skill is required to learn many mathematical concepts with understanding, and using procedures can help strengthen and develop that understanding. For example, it is difficult for students to understand multidigit calculations if they have not attained some reasonable level of skill in single-digit calculations. On the other hand, once students have learned procedures without understanding, it can be difficult to get them to engage in activities to help them understand the reasons underlying the procedure. The attention they devote to working out results they should recall or compute easily prevents them from seeing important relationships. Students need well-timed practice of the skills they are learning so that they are not handicapped in developing the other strands of proficiency. When students practice procedures they do not understand, there is a danger they will practice incorrect procedures, thereby making it more difficult to learn correct ones. Many children subtract the smaller from the larger digit in each column to get 26 as the difference between 62 and 48 see Box 4â€”2. If students learn to subtract with understanding, they rarely make Page Share Cite Suggested Citation: If students do understand, they are less likely to forget critical steps and are more likely to be able to reconstruct them when they do. Shifting the emphasis to learning with understanding, therefore, can in the long run lead to higher levels of skill than can be attained by practice alone.

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general and basic processes and principles. Evolution of the Core Progressâ„¢ learning progression for mathematics Core Progress began as a scope and sequence and.

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