What Does the CCSS Really Ask Students to Do?
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**Part 1**:

Reviewing the algebra conceptual category of the Iowa Core Curriculum proved very interesting when comparing it with Usiskin's four conceptions of algebra. Most of the standards use the terms use, create, solve, represent, write, and rewrite (Iowa). This implies procedural demonstrations of the knowledge. The main issue with procedural knowledge as Usiskin points out is that students can and do perform procedures without necessarily understanding the underlying mathematics (Usiskin). The Iowa Core Curriculum seems to put more emphasis on performing tasks than on understanding.

It seems that Usiskin's conceptions of algebra are, in a sense, a linear progression of the way algebra is learned and applied. The first conception of algebra Usiskin addresses is algebra as generalized arithmetic. This includes using variables as pattern generalizers and translating and generalizing patterns (Usiskin). Finding little evidence of this conception in the 9-12 Iowa Core Curriculum, further investigation was needed. The Iowa Core Curriculum focuses on the generalized arithmetic conception more in the seventh and eighth grade standard "Expressions and Equations." (Iowa, 54).

The second conception is algebra as a study for solving certain kinds of problems that includes solving equations with variables that have a fixed unknown (Usiskin). Believing that the intent of several of the standards is to develop further understanding beyond procedural knowledge, the manner in which the standards are written does not guarantee this further development. A student could execute a process flawlessly based on the Iowa Core Curriculum without necessarily understanding what mathematics are embedded within the process. This is dependent on how the mathematics is taught and assessed. For example, take the standard, "Use the structure of an expression to identify ways to rewrite it. **(SSE.3).**" If a student is taught how to factor the difference of two squares and assessed on that alone, the student may execute this procedure without fault; however, the student may not recognize the difference of two squares when reducing a rational function. This concept is used when finding limits of rational functions later on. Will the student recognize in a different context that anything of the form ($x^2$-$a$) can be factored this way even though $a$ is not a perfect square?

There is also evidence of the third conception of studying relationships among quantities where formulas are seen as a special type of generalization (Usiskin). For example, the standard, "Prove polynomial identities and use them to describe numerical relationships. **(A.APR.4),**" is one of several standards where variables vary. There appears to be a heavy emphasis on this conception within the conceptual domain of Functions in the Iowa Core Curriculum, especially within "Linear, Quadratic, and Exponential Models" and "Trigonometric Functions" (Iowa, 69-72). Of course, functions play a large part of the high school algebra curriculum, especially in Algebra II.

The fourth conception is the study of structure within algebra. Usiskin suggests that this is most likely found in colleges and is rarely connected to the high school mathematics curriculum (Usiskin). There was very little evidence of this in the Iowa Core Curriculum as well. In fact, most evidence was found under one of the (+) standards. For example, the standard, "(+) Know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle **(A-APR.5.)**," explores a more abstract sense to algebra.

Based on this analysis of comparing the Iowa Core Curriculum and Usiskin's four conceptual domains, it seems appropriate to say that the Iowa Core Curriculum authors view algebra in a procedural sense. Saul mimics what Usiskin said about this conception in that the structural view may be present but there may be no real understanding of the connections to algebra present (Saul). This reinforces how careful teachers must be in assessing student understanding versus regurgitation of procedures.

**Part 2:**

Several parts of the book *Developing Essential Understanding of Functions Grades 9-12* had pieces that encouraged reflection on how I have taught different concepts dealing with functions. I found "Families of Functions and Their Role in Modeling Real-World Phenomena" to be of the most value. Specifically, the area model and oblique cylinder activities provided a new perspective on how to help students gain deeper knowledge of completing the square, the quadratic formula, and modeling periodic functions with trigonometric functions.

The area model presented on page 52 not only relates two different forms of a quadratic equation but also provides a visual for completing the square. Taking it a step further to find the quadratic formula really ties it all together. Completing the square and the quadratic formula are both vital algorithms in the world of mathematics. The activity presented encourages students to do more than perform an algorithm. This activity gives students a tool for better retention and recall. Personally, I have never seen this activity before and was excited by the mathematics involved in this one simple problem as well as the extensions and connections that can be made. This one problem with the extensions tackles several standards in the Iowa Core Curriculum including:

- "Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. **(A-SSE.3B).**"
- "Solve quadratic equations in one variable. **(A-REI.4).**"
- **"**Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. **(F-IF.8).**"

In my geometry classes, we discuss oblique cylinders; however, the majority of the focus is with right cylinders. After discovering the activity on page 66, I will add this oblique cylinder activity to my geometry classes next year. No more glancing at oblique cylinders and never looking back; instead, we are going to investigate the connections to the sine and cosine functions. I wish I had been exposed to this much sooner! My students have missed out. I found evidence of this in the functions domain of the Iowa Core Curriculum. "Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline. **(F-TF.5.).**"

The function sorting activity on page 81 is another activity I am employing as an activity in my classroom. This activity provides a unique way for students to compare and contrast functions in all the different forms allowing them to make connections within families of functions. All three of these activities can be facilitated in a way that includes each of the Iowa Core Curriculum mathematical practices. These activities will provide my students with better tools and a deeper understanding of the mathematical concepts to take the learning to a level beyond procedures.

**Part 3:**

If someone is a great mathematician, does that mean they are a great mathematics teacher? I have often struggled with this question. Reflecting on my preparation to enter the world of teaching, this was the first idea that came to mind. Often in my undergrad experience, I felt conflicting information was presented to me. The mathematicians who taught the core mathematics courses and the mathematics teachers who taught the education courses did not seem to have the same pedagogy. In education courses, my teachers often told us how not to teach instead of giving us the tools for how to teach successfully. In the mathematics courses, the method of delivery was often the method we were told not to use! However, even in the education courses I feel as though I only learned theory and did not actually learn what it truly looks like to "teach" mathematics for understanding.

I concede that my undergrad occurred several years ago and many changes may have transpired over the past 15 years. Regardless of the classes taken and methods chosen for delivery, the best preparation for teaching came in one semester - the semester I student-taught. I learned more in one semester than I did in all the years before combined. I was very fortunate to have an amazing cooperating teacher. Some of my classmates were not so lucky. Unfortunately, my cooperating teacher did not teach algebra. The only exposure to algebra I had by the time I graduated was in a linear algebra course taken my sophomore year and a semester long mathematics methods course. Algebra is a major part of the high school curriculum; however, I am proof that it is possible to have very little experience as both a teacher and a student with the algebra curriculum during the undergrad experience.

With the mathematics curriculum that needs to be addressed at the high school level, to become a high school mathematics teacher, two degrees are necessary to cover all that a teacher needs to know. There is no way to develop a deep base knowledge of all the mathematics as well as study application of the mathematics to the high school classroom within four years of course work. However, this is not realistic. Therefore, I feel that there should be at least two method courses; one that focuses on algebra and functions and one that focuses on geometry and pre-calculus including trigonometry. Another key to becoming a successful mathematics teacher is having more hands on experience with several successful teachers who have different teaching styles. Even though I imagine this a nightmare to organize, the benefits would be worth it.

If additional methods courses and field experiences are not practical additions to the program, the core mathematics courses need to be taught in a way that allow education majors to experience mathematics in a manner which mirrors how to teach at the secondary level. This should include scaffolding techniques, questioning techniques, error analysis and correction of student work, multiple strategies for delivery of the mathematics, and differentiation techniques. In other words, there should be a program that is similar to the MSM program for undergrads.

Sources:

Cooney, T.J., Beckmann, S., Lloyd, G., Wilson, P.S., Zbiek, R.M., (2010). *Developing Essential Understanding of Functions Grades 9-12.* Reston, VA: National Council of Teachers of Mathematics.

Iowa Department of Education. (2010). Iowa Core Mathematics. Des Moines, IA. Retrieved from *http://iowacore.educateiowa.gov.*

Saul, M. (2008). Algebra: The mathematics and the pedagogy. In Greenes, C. E. & Rubenstein, R. (Eds.), *Algebra and algebraic thinking in school mathematics.* Seventeenth Yearbook (pp. 63-79). Reston, VA: National Council of Teachers of Mathematics.

Usiskin, Z., (1999). Conceptions of School Algebra and Uses of Variables, In *Algebraic Thinking, Grades K-12.* (pp. 7-13). Reston, VA: National Council of Teacher of Mathematics.