Curriculum Principle Project

Introduction

When our class first started talking about NCTM's (2000) Curriculum Principle, we started to categorize certain material into the traditional sequence of courses in a secondary school mathematics program. Factoring quadratic trinomials into binomials would fit into the curriculum of Algebra I, learning about the different criteria for triangle congruences would fit into Geometry, and finding the amount of money in an interest-earning bank account would go under Math Analysis. When we came across Algebra II, it seemed like there were many items in that curriculum that didn't belong there (i.e., content that I would not personally consider to be related to the branch of algebra). Many of those items would seem to fit in more concentrated courses, e.g. Statistics, but such courses are too in-depth at a high school level. Algebra II seemed to be the "grab bag" of mathematics items that were essential but didn't belong in a more relevant context. Just what exactly is supposed to be in the Algebra II curriculum, anyway, and how do Algebra II teachers interact with those requirements?

Literature Review

Teacher Interaction with Curriculum

Algebra is a very broad content area. As children, we think of 'doing algebra' as using symbolic manipulation to isolate a variable. (Vennebush, Marquez, & Larsen, 2005). In moderate-level math courses algebra is thought of as a process of solving solutions of systems of equations. When we get to the upper-level courses, we see it as proving theorems about groups and other structures with operations. "Algebra is where you find it" (Vennebush, et al., p. 86), meaning it is such a broad topic that it can be found anywhere, as long as you look for it.

Vennebush, et al. (2005) illustrate that the Algebra content standard in *Principles and Standards for School Mathematics* (NCTM, 2000) can be stretched across other content strands. They describe how algebra is used in tasks that involve Number Sense, Geometry, and Data Analysis, and further provide suggestions for altering tasks to advocate algebraic thinking. They suggest that choosing and altering tasks must be done with the intent of keeping curricular goals in mind. "Curricular goals" means curriculum within the course (short-term goals), and curriculum across the high school career and beyond (long-term goals).

The view that algebra is not a separate subject exemplifies NCTM's (2000) view that the content standards are not mutually exclusive. "Mathematics comprises different topical strands … but the strands are highly interconnected. (p. 15). "The areas described by the Standards overlap and are integrated" (p. 30).

The recommendation that Curriculum be coherent is just one of three of the NCTM's (2000) recommendations for Curriculum that make an effective math classroom. It also suggests that the mathematics curriculum should "prepare students for continued study" (p. 15) and "be well articulated across the grades" (p. 16).

Important mathematics does not include ordinary tasks and lower-level skills, but rather focuses on material that the students will find useful and interesting. Relating the theory of a mathematical concept to real-world stories and applications will amplify the importance of that concept.

The curriculum should be continuous across the grades. With a continuous road map, less time will be spent reviewing and more time will be spent learning. Also, teachers should make explicit the connections between the different courses in a typical mathematical course sequence. Identifying where courses overlap and how they connect will help teachers guide students to learn at a more accelerated rate.

Gwen Lloyd (2008) cites two studies that each offer their own spectrum of teacher-curriculum interaction, and compares the two. In short: Teachers at the far left of the spectrum follow the curriculum standards (or guide) precisely with hardly any deviation. They follow all the guide's suggestions and rely on its materials. In the middle of the spectrum, teachers are moderately interacting with the curriculum. They adopt content and tasks from the guide, but rely on their own methods and styles to carry out those tasks. On the far right of the spectrum, teachers hardly interact with the curriculum at all. They hardly use the suggested materials, sometimes even only as a spark for an idea. These teachers rely mostly on their own routines and designs.

Current Standards for Algebra II

The VDOE (2009) released a final version of the "Curriculum Framework" and a strikethrough version. With these two versions side-by-side, I was able to compare the changes made in the 2009 Algebra II SOLs. Despite the copious amounts of strikethrough, most of the material itself stayed the same. Rather than twenty discrete items, VDOE condensed the standards into twelve items and into four categories. This new format makes the Framework much easier to read and comprehend. With the curriculum organized in a meaningful way, teachers will be able to identify more easily what is expected of them, and further, will get to know their curriculum at a deeper level.

Under "Expressions and Operations," the material that remains unchanged includes performing the normal four operations on rational and irrational expressions with rational exponents; analysis and computation of arithmetic and geometric sequences and series; operations on the complex numbers; and solving equations and equalities.

In the functional area, students are expected to be able to convert between equations and graphs and make connections among similar concepts that translate between different representations of functions (e.g., that a function's zero is represented as its graph's x-intercept). Transformational graphing and nonlinear systems are also untouched.

Statistics has a small amount of material that remains the same. These standards include collection and analysis of data, equations of best fit, and real-world problems using mathematical models involving polynomial functions and direct and inverse variation.

The biggest addition is credited to statistics. With the new implementation of the Standards, students are expected to solve real-world problems using exponential and logarithmic functions (in addition to the already included polynomials) and joint variation (in addition to direct and inverse); identify and apply properties of the normal distribution; and identify, distinguish between, and perform computations of permutations and combinations.

Other material inserted into the standards includes identifying field properties of complex numbers; and being able to factor polynomials completely, wherein "each factor is a prime polynomial" (p. 1). When investigating functions, new key concepts include intervals of increase and decrease, asymptotes, end behavior, and composition.

There are miscellaneous topics deleted from the Standards, and no pair of them seems to belong in the same category. Removed topics consist of axioms of equality and order and field

properties, all conic sections (except for parabolas, which are considered functionally as second-degree polynomials), all matrix operations, linear programming, and scatterplots.

Methods

My data collection methods for this project simply consisted of a verbal discussion between myself and a few of the math teachers at my observation school. Expanding my research motives, I constructed a set of questions that I had planned to ask my mentor teacher, Mr. Noble.

Given the content required by the Commonwealth of Virginia Standards of Learning (VA SOLs), what further material have Algebra II teachers decided that students must know and therefore have additionally included in their Algebra II courses? What material in Algebra II is no longer required that Algebra II teachers have decided to sacrifice? And why have these teachers decided to implement the curriculum in this manner?

I phrased my interview questions in a way that would evoke information about how teachers interact with a standardized curriculum. I wanted to learn what they know about it and how they deviate from it, from both directions. (Deviation in one direction might be including extracurricular material (in the literal sense of the word) that is not required, thus deviation in the other direction would be removing material that is already present but not required.) My question set is shown in Figure 1.

After interviewing Mr. Noble I had decided to get more opinions, so I interviewed two of his coworkers, whom I shall name Ms. M and Ms. D. At the time of my interview, Mr. Noble and Ms. D were current Algebra II teachers, but Ms. M had no longer been teaching the course; she had been teaching upper-level courses such as Advanced Placement Statistics.

For each interviewee, I would ask a question and then let the teacher answer it in his/her own words, taking notes as he/she was talking. Sometimes I would contribute to the conversation, but my part consisted mostly of being the interviewer. When either I or my interviewee had felt like the question was sufficiently answered, I would move on to the next question. The teachers' responses are analyzed in the Results section.

Results

Teachers' Knowledge of Algebra II Curriculum Changes

All the teachers I interviewed agreed with each other on many of the changes to the Algebra II VA SOLs, but did not say much about what remained the same. They pointed out that much of the material was getting shuffled around. Some things were going out to Math Analysis and Trig, some things were coming in from Statistics, and many things from Algebra I were removed. Ms. D was the only one who gave me a date of the implementation: she stated that the final version of the changes for the Algeba II SOL was proposed in 2009 but would be first enforced in the 2011-2012 school year.

All three teachers said that the new SOLs removed a lot of material from conic sections and placed it in a different course. Conic sections included the equations and graphs of circles, ellipses, parabolas, and hyperbolas. Ms. M stated that conic sections was now in Geometry while Mr. Noble said they were in Math Analysis. Ms. D reminisced that conic sections used to be the biggest part of Algebra II. When she had first started teaching, she used to spend six weeks on the subject, and now it is almost completely removed.

Each of Mr. Noble, Ms. M, and Ms. D confirmed that statistics were being introduced to the Algebra II curriculum. Ms. M and Ms. D expanded, explaining that they would have to

introduce the normal distribution, z-scores, and finding areas under the normal curve (without using calculus of course). Measures of central tendency (mean, median, and mode) and linear regression are also part of Statistics but are already in the Algebra II standards. Ms. D, who was a current AP Statistics teacher at the time, said that many topics in the statistics unit in Algebra II would prepare her students for her class, because AP statistics uses linear regression and linear relationships of z-scores, which are under linear algebra. Mr. Noble recalled the Standards removing matrices and systems of linear equations in matrix form, while adding nonlinear systems of equations, however the VDOE (2009) indicates that nonlinear systems are present and unchanged.

Teachers' Own Deviations From the Algebra II Curriculum

I discussed with my interviewees whether there was anything not in the Standards that they have included in their teachings, and if there was anything they had removed as well. Ms. M could not think of anything that she had "sacrificed" from her curriculum, but did mention that she, among other coworkers, had to change how transformational graphing was taught. The desired approach, entitled "Equations and Graphs" by Mick, Bazak, and Farkas (unpublished), was more conceptual. Even though this approach took more time, Ms. M said, "The payoff is huge."

Ms. M said she always loved Cramer's Rule (an intricate theorem involving matrix manipulation, multiplication and determinants) and would always introduce it in her classroom after the SOLs if she had time. She justified that Cramer's Rule was a useful supplement to matrices, determinants, and systems; has further applications; extends the concept of linear systems; and is a peek into operations research.

Ms. D, on the other hand, took the opposite approach. Matrices and determinants were one of the topics she removed from her classroom, because she had to make time for other topics. Among matrices and determinants were logarithms. She had expressed that there was simply too much material, and that teachers who didn't have time to cover important concepts (such as logarithms) would rely on the teachers who had higher-level classes to 'pick up the slack.' Thus the responsibility of logarithms, for example, falls on the Math Analysis (or which ever course typically comes after Algebra II) teachers. Ms. D did not give me specific examples of material she has optionally included in her classroom, but did explain that she teaches a lot of material that is important, and that the students "won't get [it] anywhere else." She was proud of exploring extra material—or the same material but deeper—in her honors classes. She said that even though this material isn't in the Standards, it was necessary for higher level courses. She does not like to teach to the test.

Mr. Noble opposed Ms. D in that he liked to incorporate the visualization and meaning of exponential and logarithmic functions. He taught his students how to solve these equations, and liked to pose "more difficult" problems (which he then specified were equations with harder radicals and absolute values) when he had time after the SOLs. There were many things Mr. Noble excluded from his curriculum. Theorems I don't remember hearing before were the Rational Root Theorem and the Remainder and Factor Theorems, which he both cut from the material. He also said he had decided not to teach Completing the Square because there was no need: conics is taken out. Among other things he removed were story problems in linear programming, and things that were to be memorized rather than learned (e.g. the shapes of graphs, certain formulae, etc.). He expressed that he wanted to take out material that involved more theory than real-world application, because he wanted to make sure his students were

interested and learning something they viewed was relevant. This is consistent with NCTM's (2000) second suggestion for Curriculum.

Mr. Noble expressed how difficult it was to remove optional material at will, because the Standards continue to add more material without removing any. Thus he had to make careful decisions on what not to teach.

Conclusions

My interviewees' responses were mostly consistent with the Curriculum Framework (VDOE, 2009). There were a few inaccuracies, but this may have been due to memory faults in the teachers, which a simple review of the Standards would fix.

The teachers added extracurricular material to their courses under the intentions of NCTM's (2000) three recommendations for Curriculum: longitudinal coherence, latitudinal coherence, and relevance. The extracurricular material that was subtracted was done only as a 'necessary evil,' due to time constraints or irrelevancy. I did find it interesting that all three teachers disagreed on

Ms. M optionally included Cramer's Rule, a theorem on matrix determinants, while Ms. D completely removed matrices from her curriculum. In a similar manner, Mr. Noble said he liked to include graphical and equation analysis of exponential and logarithmic functions while Ms. D also removed those from her curriculum. I deduce that Ms. D is covering a lot less material in her classes, but much more in depth. This is probably because more of her classes are Honors classes.

Implications for Future Research

Upon reflection of my methods, I realize that they are quite subjective and didn't elicit as much of a factual response as I intended. I have two alternate suggestions for future research.

The first option is to use the same question survey, but spend more time in interview with the teachers. I would have liked to sit down and go through lesson plans, picking out explicit content and material that is not present in the Standards. Another way to do this is to gather a longitudinal collection of one teacher's lesson plans and compare across time.

My second, alternate, suggestion would be to make the survey shallower but more explicit, and gather a much larger number of subjects. I would have a poll, questionnaire, or check sheet that calls for unambiguous data: what specific topics teachers have taught in their classrooms. I would send the poll to about 10 or 15 teachers, to get an accurate response so that I could notice trends and patterns.

As the NCTM (2000) says, a curriculum is never static. With more information about how teachers interact with the standardized curriculum, and with cross-references to other literature on how students respond, we can get a better idea of how to change it in the interest of our students.

Appendix

1. What can you tell me about the current Standards, regarding the content of the Algebra II curriculum? Were there any changes from last year?
2. What content have you purposefully included in your teaching of Algebra II that is not in the current Standards? Why do you include this material?
3. Is there any content that you have traditionally included, but have decided to sacrifice this year? Why have you decided so? Is that content required to be taught by the Standards?

Figure 1. My set of questions for Algebra II teachers I had interviewed.

References

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