BROADER INTENTIONS: EXPLORING THE ROLE OF AIMS FOR SCHOOL MATHEMATICS IN TEACHER CURRICULAR DECISION MAKING

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The current study develops theories about why the system of mathematics education in the United States is struggling to meet many of its beyond-the-classroom aims by exploring to what extent and how aims permeate curriculum planning and enactment systems and the role that aims play in the decision making of teachers in these systems. It examines the written, planned, and enacted curriculum of three high school algebra lessons. It finds that aims influence the decision making of all three teachers, but permeate the lessons differently in ways that are potentially explained by teacher aims, the topic taught, the types of evident aims, the number of years the teacher has been teaching, and how long they have been using their textbook.

Keywords: Curriculum, Curriculum Analysis, Curriculum Enactment

Secondary mathematics students often lament "Why do I have to learn this stuff?" There is good reason to take this question seriously. There are a number of broader goals that school mathematics is intended to support and the system of mathematics education in the United States is struggling to meet many of these aims. For example, US schools have had limited success developing students' ability to use quantitative information to make day-to-day decisions (Kastberg et al., 2016), participate in the labor market (Carnevale & Desrochers, 2003; Deloitte, 2015) and succeed in college STEM majors (Ganter & Barker, 2004).

I refer to the rationales for teaching and learning school mathematics, such as developing students' abilities to use mathematics to make day-to-day decisions or preparing students for the labor market, as *aims for school mathematics.* These are the beyond-the-classroom benefits that are attributed to the teaching and learning of mathematics in K-12 schools. The system's failure to achieve many of these aims raises an important question: Are aims considered in the curricular work of mathematics education decision makers and if so, how?

The current exploratory study adds to what is known about curricular decision-making systems by examining the curricular stages and changes that occur in three different high school algebra lessons as the teachers transform them from written textbook lessons to plans to an enacted lesson perceived by students. This examination is guided by the following research questions: 1) *To what extent and how do aims for school mathematics permeate these curriculum planning and enactment systems? 2) What role do aims for school mathematics play in the decision making of these teachers in these lessons?*

Theoretical Framework

I describe any desired ends of school mathematics as *curricular intentions*. I refer to classroom-based curricular intentions that are oriented toward improving students' mathematical proficiency (National Research Council, 2001) as *mathematical goals* and beyond-the-classroom benefits that mathematical proficiency provides as *aims for school mathematics*.

In order to understand the role that aims play in curricular decision making, different aims need to be identified and categorized because it is likely that the role of aims will differ depending on the type of aim invoked. I have compiled and categorized a list of aims mentioned in a variety of policy and research literatures and categorized them based on common characteristics (e.g., Geiger et al.,

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2015; González & Herbst, 2006; Gutiérrez, 2017; NCTM, 2000; Sinclair, 2001; Steen, 2001; Usiskin, 1980; Williams, 2012) (see Figure 1).

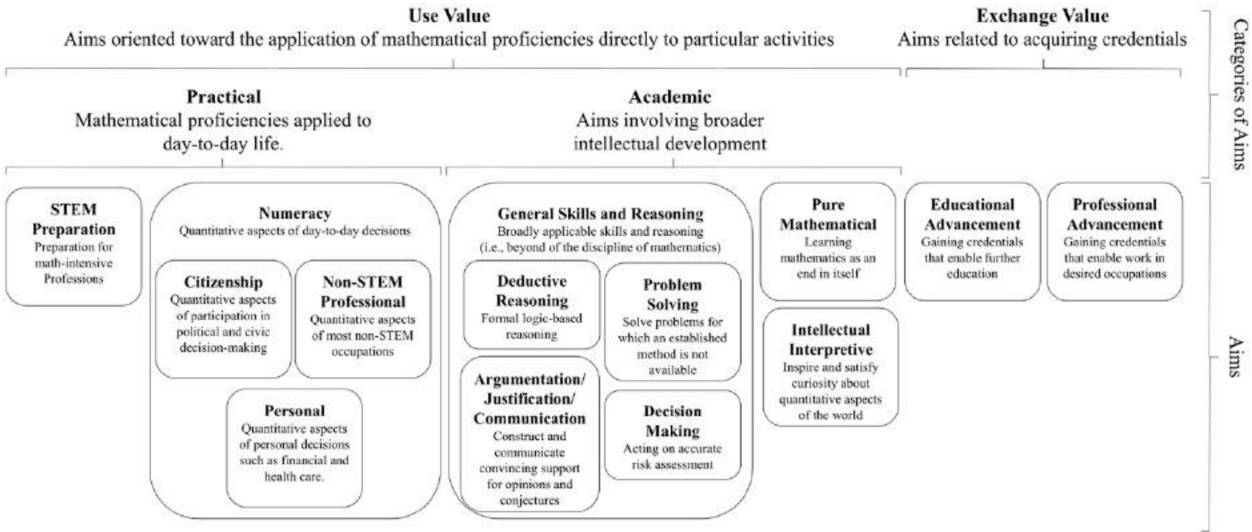

Figure 1: A Conceptual Framework for Aims for School Mathematics

Curricular decision making takes place within *curriculum policy, design, and enactment systems*. These systems include three stages: 1) the curriculum formulated before instruction (*intended)* which includes system-level expectations for student learning, textbooks, and teacher plans; 2) the curriculum that emerges as students and teachers interact (*enacted)*, and 3) the curriculum learned by students (*student learning)* (Remillard & Heck, 2014).

In planning and enacting curriculum, teachers vary widely in the extent to which they modify written materials (Remillard, 2005; Sherin & Drake, 2009). This variation can be described as a continuum in which some offload their design decisions to text, some adapt the text, and other improvise (Brown, 2009). Teachers' skill in making these decisions in order to achieve their intentions can be described as their *pedagogical design capacity* (Brown, 2009). One important element of this capacity is a teacher's developing knowledge of how their curriculum materials function in their particular context, their *curriculum context knowledge* (Choppin, 2009).

A key issue in investigating the role of aims in curriculum decision making is the extent to which aims permeate the system. At one extreme is the *low permeation* model whereby a particular set of mathematical goals, both process and content (e.g., NCTM, 2000; NGACBP/CCSSO, 2010), are established as supportive of the range of aims set for the system and teachers focus on mathematical goals without explicitly considering aims. At the other extreme is the *high permeation* model adopted by teachers who place aims at the center of their day-to-day decision making.

In investigating aims permeation, it is important to determine the types of curricular activities (what I will call *curricular structures*) in which aims are evident. This study investigates three kinds of structures, *tasks*, *discussions*, and *connectors*. I define tasks as anything students do that involves more than conversation. I define discussions as the verbal substance of the lesson. Connectors are verbal or written exposition that come before a task or discussion to frame it, after a task or discussion to summarize it, or between lesson elements as a transition. Tasks can be further categorized by their contextuality as not contextual (*mathematical)*, containing all of the complexity of a real-life problem (*authentic contextual)* somewhat simplified but still might reasonably occur outside of the classroom *(practical contextual),* or contextual but unrealistic (*prototypical)* (Csikos & Verschaffel, 2011; Palm, 2009; 2018).

Methods

The current study examines the curricular systems of three high school algebra teachers in economically and racially diverse high schools. Tobin[1] is in her seventh year of teaching, Megan in her fourth, and Rose in her third. Tobin and Megan are in their second full year using their text while Rose is in her first full year using hers (although she previously used elements of it).

For each lesson, data was collected from teacher interviews, classroom observations, student interviews, and textbooks. General interviews were conducted with teachers to learn their perspective on aims for school mathematics, the outside forces that impact their decisions, and how they use the written curriculum provided to them. Teachers were also interviewed before observed lessons, and teachers and up to four students per classroom were interviewed after each lesson. All interviews were audio recorded and transcribed. Lessons were observed and audio recorded. Additionally, Tobin and Megan's first days of school were observed and audio recorded and Rose described her first day of school in an interview. Introductory textbook materials were collected along with observed textbook lessons, relevant teacher-created materials, and pictures were taken of the classroom environment during the lesson.

Textbook overviews and general interviews for each teacher were analyzed for evident aims. A thematic analysis (Braun & Clarke, 2006) was conducted, using the previously described conceptual framework as initial codes, to create a coherent description of the textbook or teacher's perspective on aims for school mathematics. The lesson-based data was first analyzed to determine the structure of the lesson. Then the written, planned, and enacted stages were coded for stated intentions of the lesson, any other evident aims and contextual intentions, and any other mathematical goals that were connected to aims or the stated intentions of the lesson. Furthermore, any curricular decision described by the teacher was coded for any intentions cited by the teacher as justification for that decision.

Findings

The practical aim of effective financial decision making is evident in all curricular stages of Tobin's lesson as well as in her decision making. The stated intention of Tobin's textbook lesson is to use what students know about linear and exponential functions to help them understand the difference between simple and compound interest. In the lesson itself, there is considerable attention paid to developing a continuous model for calculating compounding interest. In her planning and enactment, Tobin makes significant adaptations that she describes as focusing the lesson on the value of interest in general and the power of compounding. This shift focuses the lesson more explicitly on financial decision making and less on the underlying mathematics.

In the textbook lesson, the aim of financial decision making is evident in an opening discussion, an opening written passage, and four practical contextual tasks. There is also a practical contextual task and a lesson summary in which the aim is not evident. Tobin's adaptations in her planning all relate to the aim. They include changing the framing and summaries of tasks, adding an authentic contextual task, a prototypical contextual task, and some teacher exposition, modifying tasks, and eliminating tasks. In enactment, Tobin makes further aims-related changes. She adds task framings and summaries, more teacher exposition, two personal asides, and gets four unplanned student-initiated conversations. The two students interviewed from Tobin's class cite financial decision making as evident in the lesson.

Aims are evident in all curricular stages of Rose's lesson as well as in her decision making but less so than in Tobin's lesson. Furthermore, Rose's perspective on aims differs from her text book so her adaptations change the nature of evident aims. The stated intention of Rose's textbook lesson is

[1] All names are psudonyms.

solving real world problems using systems of linear equations. In the written lesson, this practical aim is evident in two suggested class discussions and four practical contextual tasks, three of which are in a business context. Rose, however, is more focused on her students' general problem solving skills and in having them collaborate so they will enjoy the lesson and thus be more likely to consider STEM careers. As a result, her adaptations from planning to enactment end up eliminating the practical tasks. She uses prototypical tasks and modifies them to incorporate more problem solving and collaboration. Interestingly, despite these adaptations, two of the four students interviewed after this lesson identified the practical use of systems of equations as an aim for the lesson.

Unlike Tobin and Rose's lessons, aims are not evident in Megan's lesson, yet the aim of communication drives some of Megan's decisions and multiple aims are perceived by students. The stated intention of Megan's written lesson is for students to be able to add and subtract rational expressions. Megan's aim-related adaptation is to ask all of the groups to present their solutions to the first task in the lesson, a change that she explicitly ties to the aim in interviews, but not in the class. Despite this lack of evident aims in the written and enacted lesson, two the four students interviewed identify the aim of communication as evident in the lesson and one of four identifies collaboration and problem-solving. This is consistent with passages in the textbook introduction and teacher exposition on the first days of school that link mathematical goals such as communication, collaboration and problem-solving to broader aims.

Conclusions and Discussion

Thus, there are a variety of curricular structures in which aims can be evident, including a range of tasks, discussions, and connecting activities. Most notably, Rose and Tobin's textbook lessons and planning demonstrate how authentic contextual tasks can make practical aims evident in a lesson. Tobin's enactment suggests that aims-related personal asides and summaries may make aims evident in ways that register with students as they seem to inspire both student-initiated conversation and student-perceived aims. In contrast, Rose's enactment suggests that a lack of these structures may lessen the impact of evident aims. It also demonstrates the power of the teacher to eliminate aims to which she is not attending. Megan's lesson shows that intending to support mental discipline aims is not the same as making them evident in the lesson. However, it also suggests that explicit connection of mathematical practices to mental discipline aims in overview materials and general teacher exposition may have an impact on student perception of aims in later lessons even if the aims are not explicitly evident in the lessons themselves.

The differences in evident aims between these three lessons may be due, in part, to the topics. It is unsurprising that lessons on exponential functions and systems of equations would be more clearly connected to practical aims than one on simplifying rational functions. However, the finding that Tobin more effectively adapts her lessons suggests that more experience with her curriculum may have helped her develop more curriculum context knowledge (Choppin, 2009) and more years in the classroom may have allowed her to develop more pedagogical design capacity (Brown, 2009). Megan's use of overviews to link goals to aims may suggest another element of curriculum context knowledge and pedagogical design capacity.

Overall, this analysis suggests that aims can, indeed, permeate curricular processes, and provides some initial ideas for how this permeation may be indicative of teacher skill in using curriculum and how it might influence the achievement of aims. It lays the groundwork for future research to explore whether and how this kind of curricular work can, in fact, support the achievement of aims for school mathematics.

References

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Brown, M. W. (2009). The teacher-tool relationship: Theorizing the design and use of curriculum materials. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 17–36). Routledge.

Carnevale, A. P., & Desrochers, D. M. (2003). *Standards for what?: The economic roots of K-16 reform*. Communication and Public Affairs, Office of Assessment, Equity, and Careers, Educational Testing Service.

Choppin, J. (2009). Curriculum-context knowledge: Teacher learning from successive enactments of a standards-based mathematics curriculum. *Curriculum Inquiry*, *39*(2), 287–320. https://doi.org/10.1111/j.1467-873X.2009.00444.x

Csikos, C., & Verschaffel, L. (2011). Mathematical literacy and the application of mathematical knowledge. In B. Csapó & M. Szendrei (Eds.), *Framework for diagnostic assessment of mathematics*. Nemzeti Tankönyvkiadó.

Deloitte. (2015). *The skills gap in U.S. manufacturing 2015 and beyond*. Manufacturing Institute. http://www.themanufacturinginstitute.org/Research/Skills-Gap-in-Manufacturing/Skills-Gap-in-Manufacturing.aspx

Ganter, S. L., & Barker, W. (Eds.). (2004). *The curriculum foundations project: Voices of the partner disciplines*. Mathematical Association of America.

Geiger, V., Goos, M., & Forgasz, H. (2015). A rich interpretation of numeracy for the 21st century: A survey of the state of the field. *ZDM*, *47*(4), 531–548. https://doi.org/10.1007/s11858-015-0708-1

González, G., & Herbst, P. G. (2006). Competing arguments for the geometry course: Why were American high school students supposed to study geometry in the twentieth century? *International Journal for the History of Mathematics Education*, *1*(1).

Gutiérrez, R. (2017). Living mathematx: Towards a vision for the future. In E. Galindo & J. Newton (Eds.), *Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 2–26). Hoosier Association of Mathematics Teacher Educators.

Kastberg, D., Chan, J. Y., & Murry, G. (2016). *Performance of U.S. 15-year-old students in science, reading, and mathematics literacy in an international context: First look at PISA 2015* (No. 2017–048). National Center for Education Statistics. http://nces.ed.gov/ pubsearch

National Research Council. (2001). *Adding it up: Helping children learn mathematics* (J. Kilpatrick, J. Swafford, & B. Findell, Eds.). National Academies Press.

NCTM. (2000). *Principles and standards for school mathematics*. National Council of Teachers of Mathematics.

NGACBP/CCSSO. (2010). *Common core state standards for mathematics*. National Governors Association Center for Best Practices, Council of Chief State School Officers.

Palm, T. (2009). Theory of authentic task situations. In Lieven Verschaffel, Brian Greer, Wim Van Dooren, & Swapna Mukhopadhyay (Eds.), *Words and worlds: Modeling verbal descriptions of situations* (pp. 3–19). Brill | Sense. https://doi.org/10.1163/9789087909383

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, *75*(2), 211–246.

Remillard, J. T., & Heck, D. J. (2014). Conceptualizing the curriculum enactment process in mathematics education. *ZDM*, *46*(5), 705–718. https://doi.org/10.1007/s11858-014-0600-4

Sherin, M. G., & Drake, C. (2009). Curriculum strategy framework: Investigating patterns in teachers' use of a reform□based elementary mathematics curriculum. *Journal of Curriculum Studies*, *41*(4), 467–500. https://doi.org/10.1080/00220270802696115

Sinclair, N. (2001). The aesthetic "is" relevant. *For the Learning of Mathematics*, *21*(1), 25–32.

Steen, L. (2001). *Mathematics and democracy: The case for quantitative literacy*. The National Council on Education and the Disciplines. http://www.maa.org/publications/maa-reviews/mathematics-and-democracy-the-case-for-quantitative-literacy

Usiskin, Z. (1980). What should not be in the Algebra and Geometry curricula of average college-bound students? *Mathematics Teacher*, *73*(6), 413–424.

Vos, P. (2018). "How real people really need mathematics in the real world"—Authenticity in mathematics education. *Education Sciences*, *8*(4), 195. https://doi.org/10.3390/educsci8040195

Williams, J. (2012). Use and exchange value in mathematics education: Contemporary CHAT meets Bourdieu's sociology. *Educational Studies in Mathematics*, *80*(1–2), 57–72. https://doi.org/10.1007/s10649-011-9362-x