5-2-2019

Curriculum Analysis: Hardin Middle School Math

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A Scholarly Paper

Submitted to The Graduate School

University of Missouri-St. Louis

in partial fulfillment of the requirements for the degree

Educational Specialist

In

Educational Administration

May 2019

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Abstract

The City of St. Charles School District, particularly Hardin Middle School (HMS), has routinely been outperformed by its St. Charles County counterparts in math. Consequently, it is necessary to evaluate curriculum development, implementation, and resources to begin to determine the causal factors of low performance. If HMS' curriculum is not effectively facilitating high quality instruction, it could be a leading factor in their low performance. To determine whether HMS' curriculum is impacting student achievement the research will conduct an analysis of both the written and implemented (textbook) curriculum. The analysis will be designed to determine whether the district's current curriculum can facilitate best teaching practices.

Introduction

The City of St. Charles School District faces a crossroads in its math departments, especially at the secondary level. Student achievement on the Missouri Assessment Program (MAP) for 7^{th} and 8^{th} grade has historically hovered near the state average. Despite two grade level cohorts scoring above the state average, the data still reflects that over 50% of students are scoring below grade level. For example, in 2018, the percentage of students scoring proficient or advanced on the 7^{th} grade math exam was 2.2 percentage points above the state average and 8^{th} grade achievement was 11.1% above the state average (MO DESE, 2018). The 8^{th} grade scores were abnormally high this past year because, for the first time, all 8^{th} graders took the MAP test including the over one hundred students enrolled in Algebra 1 - roughly one third of the grade. This was a departure from years previous and from many neighboring school districts, whose 8^{th} graders enrolled in Algebra 1 took the Algebra 1 End of Course (EOC) exam. When the 8^{th} graders enrolled in Algebra 1 are removed from the data set, the math achievement is more aligned with the state average of roughly 30% proficiency.

SCSD also ranks last in math achievement when compared to the four surrounding districts in St. Charles County. The deficiencies in performance create an educational equity issue for the district. To remain a viable option for families in the area, the district must place a focus on improving math instruction and consequently achievement. For the district to improve achievement, it must first understand what current research-based practices are influencing mathematics instruction. Teachers cannot systemically improve their instruction if the district does not invest resources into understanding and training teachers in best practices. Once best practices are identified, the district can determine whether its curriculum is aligned. Curriculum is the foundation to any course and could be a leading factor in poor student achievement.

Literature Review

The philosophies influencing math instruction have periodically shifted since the 1960s. During the late 1960s there was a growing shift from the tenants of the *New Math* reform characterized by a primary focus on college-bound students with an emphasis on mathematical structure and the development of patterns, towards a *back to basics* approach (Herrera & Owens, 2001). The 1970s and 80s saw a continued focus on computation, algorithms, and algebraic manipulation as the perceived foundation to increasing mathematics achievement (Herrera & Owens, 2001). As American students continued to lag behind other industrialized nations in math achievement, experts pushed for a renewed approach to mathematics instruction.

Traditional methods did not improve achievement or translate into more students continuing to high level math courses; consequently, a transition from a procedural to a conceptual focus marked the latest movement in math instruction (Hiebert, 2003; Herrera & Owens, 2001). In 1980, the National Council of Teachers of Mathematics (NCTM) produced their *Agenda for Action* advocating a transition in content and pedagogy. It represented a focus on "problem-solving, spatial visualization and awareness, mathematics as communication, technological literacy, and appropriate computation skills became the new basics for school mathematics" (Harwell et al., 2007, p. 73).

NCTM furthered the shift to a conceptual focus by developing the *Curriculum and Evaluation Standards for School Mathematics* in 1989 and *Professional Standards for Teaching Mathematics* in 1991 to encapsulate the shift in priorities. In addition to a focus on how students develop an understanding for mathematical concepts and the relationships within mathematical concepts was a commitment to applying those concepts in the real world (Harwell et al., 2007). The shift also was a departure from previous eras by emphasizing a mathematics curriculum for all students, not just those bound for college (Herrera & Owens, 2001). In 2000, NCTM produced *Principles and Standards for School Mathematics* reflecting what researchers found to be the most current understanding of best practices. This aligned with a shift in math instructional research focused on analyzing high leverage practices of the most effective math teachers (Taylor, 2016). Continued research in mathematical instruction drew from a decade's worth of NCTM publications to determine a series of themes found in effective teachers and related to improving student achievement: a conceptual understanding in the development of learning, problem-solving, modeling with mathematics and the use of multiple representations, discourse, and purposeful questioning.

Mathematics instruction can be categorized by into five types of knowledge, two of which are conceptual and procedural (Kilpatrick, Swafford, and Findell, 2001). An emphasis on a conceptual understanding to make meaning of topics requires a *concepts first* approach, rather than a procedure or algorithm first approach to learning (Putnam, Heaton, Prewat, & Remillard, 1992). Within a conceptual paradigm the learner shifts from a passive recipient of knowledge to that of an active constructor of knowledge (Anthony, 1996, p. 349). A constructivist and concepts first approach to learning focuses on a student's ability to construct mathematical concepts through drawing on previous experiences and understandings to learn new topics (Skott, 2004; Carpenter & Lehrer 1999; Flores, Koontz, Inan, & Alagic, 2015). Students construct their knowledge, elaborate on their thinking and reasoning, and modify their thought process through discussion.

The ability of the teacher to connect previous learning to new learning also allows students to more proficiently apply their knowledge to solve new and unique problems (Carpenter & Lehrer, 1999; Suh, 2007; Flores et al., 2015). Flores et al. (2015) argue that "conceptual knowledge is networked, connected, and rich in relationships between concepts," which allows for an increase in student understanding (p. 272). An emphasis on conceptual learning has also been found to support student retention of learning, prevent common errors, and facilitate a stronger procedural fluency through a foundation in the underlying concepts within the procedure (Suh, 2007). Research has found that constructivist influenced tasks or activities have increased student confidence as well as student achievement (Hickey, Moore, & Pellegrino, 2001). Another positive byproduct of instruction grounded in conceptual understanding is an increased capacity for *procedural flexibility*. The National Research Council describes procedural flexibility as the ability to solve a myriad of problems with flexibility and efficiency (2001). Solving unfamiliar and unique problems is incredibly difficult for students who are focused on algorithms and process. Moving students towards a procedural flexibility is going to give them confidence in attacking all types of problems. Mathematics achievement is grounded in a student's ability to effectively solve problems; a conceptual focus is the foundation to masterful problem-solving.

A consistent theme within reform movements, curriculum objectives, curricular resources, and the emergence of the education internet community is strategies and instructional approaches intended to improve children's capacity for problem-solving.

The interest in problem-solving surged during the 1980s and has returned to the forefront with the popularity of problem-based learning (Inglis & Foster, 2018). Problem-solving is “an individual’s capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious” (OECD, 2013, p. 122). Problem-solving increases students’ capacity for *strategic competence* or the ability to formulate a strategy, represent that strategy, defend or justify the strategy, and then determine a solution (NRC, 2001; Suh, 2007). Most importantly, research has found that an emphasis on problem-solving strategies is an integral component of increasing student performance (Vashchyshyn & Chernoff, 2016; Wernet, Lawrence, & Gilbertson, 2016). Incorporating problem-solving as a driving force in a district philosophy of math instruction is a conduit to embedding other effective instructional practices.

The use of mathematical modeling and the connections of multiple representations is elemental in developing effective problem-solvers (Flores et al., 2015). Wernet et al. (2016) argue that modeling should be a consistent part of the learning process as an aid for translating mathematics thinking. A greater conceptual understanding relies heavily on a student’s ability to make sense of new topics. Sense-making is elevated by the routine implementation of mathematical modeling and the expectation that students discover connections between multiple visual representations (Wernet, et al, 2016; Lamon, 2001; NCTM 2000). A sense-making competency is improved by modeling because it aids students in visually representing their thinking, drawing connections between algorithms, patterns, and visual models, and flexibly developing strategies for solutions (Lamon, 2001; NCTM, 2000, Lesh, Cramer, Doerr, Post, & Zawojewski, 2003). Regular utilization of modeling tasks and/or tasks requiring students to interact with multiple representations has shown to deepen student's mathematical reasoning, especially when attempting problems where a solution is not found by simply setting up the algorithm (Flores et al., 2015). When students model their mathematical processes and draw connections between different representations they are able to deepen their thinking and apply their learning to find solutions.

To construct knowledge efficiently, students need to discuss and critique the reasoning of others through discourse. The research is abundant, implementing discourse strategies into math classrooms allows students to: develop mathematical arguments, justify their ideas and processes, understand that math makes rational sense, connect relationships between multiple ideas, explore and correct errors, and take ownership over learning (Suh, 2007; Kazemi & Stipek, 2001, Munter, 2014, Hufferd-Ackles, Fuson, & Sherin, 2004). Similarly, classrooms where students are able to verbalize their thinking have shown to elevate students' ability to justify and reason as well as increase student achievement (Suh, 2007). Teachers should engage students in creating verbal math arguments (Lampert, 1990) and then utilize those arguments and justifications to scaffold learning and deepen understanding by drawing on students' explanations to ask follow up questions, offer alternative methods, and emphasize important ideas (Cobb, Boufi, McClain, & Whitenack, 1997, NCTM 2014). Munter (2014) argues that discourse is not coincidental, teachers must create tasks, implement classroom routines, and value student thinking for discourse to effectively aid student mastery. Strategies such as cooperative learning, math talk learning communities, *number talks*, and discussion protocols can effectively move students towards a discourse model (Summers, 2006, Hufferd-Ackles et al., 2004).

The aforementioned best practices and instructional philosophies are all enhanced by the teacher's use of questioning. There has been a shift in math instruction from questioning to determine a solution to questioning as a means to uncovering the mathematical reasoning embedded within an answer (Hufferd-Ackles et al., 2004). Quality instruction requires teachers to pose questions as a means to drive student investigation, assist students in explaining their strategies and thinking, deepen students' critical thinking, and for teachers to better understand the thought process of their students (Borko, 2004). Questioning is cognitively demanding for students, challenges their perception and thought process, and pushes them to think critically about presented material. Skott (2004) argues, questioning is used "to interpret the individual student's current understandings and unobtrusively challenge them by attempting to provoke relevant mental disequilibria in order to sustain [their] cognitive development and procedural competence" (p. 238). Utilizing questioning as an instructional practice not only facilitates students' conceptual understanding, but also builds their ability to maintain a strong procedural fluency.

An effective curriculum is a "subset" of effective teaching; however, highly effective teaching practices, like the ones promoted in the most recent wave of instructional research, are difficult to implement and thus curriculum becomes increasingly integral to facilitating student learning (Taylor, 2016). The definitions of curriculum are vast and curriculum itself can be categorized in multiple ways from the intended, ideal, or written curriculum, to the implemented, adopted, or textbook driven, to the achieved, real, or tested (Clements, 2002; Burkhardt, Fraser, & Ridgway, 1990; Hjalmarson, 2008). Hjalmarson (2008) describes curriculum as a "systemic instructional endeavor including pedagogical interaction between teachers and students using tangible materials" (p. 593). Clements (2002) argues that curriculum is "an instructional blueprint and set of materials for guiding students' acquisition of certain culturally-valued concepts, procedures, intellectual dispositions, and ways of reasoning" (p. 601). Regardless of definition specifics, studies have determined that curriculum is important for improving student achievement (Reys, Reys, Lapan, Holliday, & Wasman, 2003; Taylor, 2016). If curriculum impacts student achievement, Taylor (2016) argues that some curricula is better than others, however research has difficulty determining one curriculum model or design that works for all students. If the shift in curricular design has moved to embodying and facilitating best teaching practices, and if curriculum can be evaluated as weak or strong, it is important for school districts to evaluate whether their curriculum provides teachers with a capacity to employ best practices.

Innate to curriculum design are curricular materials, e.g. textbooks. Textbooks often dictate, or at the very least direct, what content is taught, how students acquire knowledge, and what instructional practices are emphasized (Weiss, Banilower, McMahon, & Smith, 2001; Doabler, Fien, Nelson-Walker, & Baker, 2012). Adopting an effective math textbook is also one component of strengthening core instruction (Doabler et al., 2012). Given these realities, it is important to understand whether a chosen curricular material like a textbook is providing "teachers with a solid instructional base for teaching key math concepts and skills" (Doabler et al., 2012, p. 200). The City of St. Charles School District, and particularly Hardin Middle School, has a responsibility to review both their written curriculum and curricular resources to determine whether they are providing a solid foundation for teachers to implement best practices.

Sample

The City of St. Charles School District contains fourteen schools, including a technical, business, and alternative school, and almost five thousand students. It is the second smallest school district in St. Charles county, but the most racially and socioeconomically diverse. Over 27% of the student population is non-white, 6.7% are English Language Learners, and 40.6% are eligible for free or reduced price lunches.

This study specifically examined the curriculum at Hardin Middle School (HMS) because the K-6 curriculum was analyzed and rewritten over a year ago and high school achievement is directly impacted by $7^{th}/8^{th}$ grade proficiency. Hardin is a 7/8 building and the only middle school in the district. The student population strongly mirrors district wide demographics and hovers around seven hundred students. HMS offers four math courses: 7^{th} grade math, 7^{th} grade pre-algebra, 8^{th} grade pre-algebra, and algebra 1 for 8^{th} graders. The two pre-algebra courses utilize the same curriculum guide, but technically the 7^{th} grade course is accelerated.

For this analysis, the researcher evaluated the 7^{th} grade and pre-algebra curriculums. There are thirty unit guides in the 7^{th} grade curricular documents and twenty-four within the 8^{th} grade (Appendix A). HMS no longer has its students take the algebra 1 EOC and has consequently changed what is covered in the 8^{th} grade version of algebra 1. Consequently, the 8^{th} grade Algebra 1 course at Hardin Middle no longer aligns with the Algebra 1 courses taught at the high schools. Examining a curriculum, in this case the high school version of Algebra 1, did not add value to this analysis or future recommendations because it does not align with the course taught at Hardin Middle. There is however, no official 8th grade Algebra 1 curriculum; it is currently being written for board approval. All of the curriculum guides follow the same template design and include the same components allowing for an ease of analysis. The curriculum is made available to all stake holders through the district's website.

The curricular resources being analyzed are two Prentice Hall Mathematics texts published by Pearson. The textbooks were published in 2010 and adopted by the district along with the written curriculum in 2012. The resource is used for both the 7th grade math and Pre-Algebra courses. It follows a consistent structure throughout both of the books in an attempt to create consistency and alignment for students. Prentice Hall Mathematics claims their texts include real-world applications, interdisciplinary applications, labs and hands on learning, technology connections, projects, problem-solving activities, assessments, and a minor online component. There are not enough copies of the text for each student to take home; only class sets are available to teachers.

Methods

To determine the effectiveness of the district's written curriculum and resources they were evaluated using a researched based standard. The National Council of Teachers of Mathematics (NCTM) *Effective Mathematics Teaching Practices* (2014) was the researchers preferred tool for gauging curricular effectiveness. NCTM is the largest organization for mathematics teachers in North America. NCTM was influential in developing mathematics practice and teaching standards initially utilized to create numerous standards based textbooks. When reviewing the *Effective Mathematics Teacher Practices* they incorporated all of the instructional practices discussed in the literature review. The district sends teachers to NCTM conferences, has a multitude of teachers who are NCTM members, and has utilized curricular resources whose creation was based in NCTM standards. Similarly, if these are the teaching practices developed by the leading mathematics education organization then the district's curriculum and resources should be effective tools in the facilitation and implementation of best teaching practices. An explanation of the eight practices is detailed in Figure 1 (NCTM, 2014).

Figure 1

Establish mathematics goals to focus learning. Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Implement tasks that promote reasoning and problem solving. Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
Use and connect mathematical representations. Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.
Facilitate meaningful mathematical discourse. Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
Pose purposeful questions. Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.
Build procedural fluency from conceptual understanding. Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.
Support productive struggle in learning mathematics. Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.
Elicit and use evidence of student thinking. Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

To utilize the NCTM *Effective Mathematics Teaching Practices* as a curriculum evaluation tool, the practices must be turned into a rubric (figure 1). I used a 0 to 3 scale to evaluate the district's current curriculum based on the eight best practices. I specifically analyzed the written curriculum that is made available on the district's website, not only for teachers, but the community at large. An overall mean rating of two signified a curriculum capable of facilitating the *Effective Mathematics Teaching Practices.*

SCSD's curriculum is broken into eleven sections, all of which were analyzed: essential course outcomes, equity/workplace readiness, instructional method (strategy), standards, learning activity, assessment activity, evaluation, resources, enrichment exercises, correction exercises, and special needs. Each section provided the researcher with a representation of the district's mathematical paradigm and instructional philosophy. The researcher assigned their rating based only on what is in the curriculum documents and not based on any experience with the district or its teachers.

Figure 2

Effective Mathematics Teaching Practices	**3**	**2**	**1**	**0**
Establish mathematics goals to focus learning	Clear and specific math related learning goals	Vague or generic math related learning goals	Learning goals unrelated to math	Absence of learning goals
Implement tasks that promote reasoning and problem solving	Components explicitly promote reasoning and problem solving in all units	An emphasis on reasoning and problem solving can be implied	Reasoning and problem solving are addressed in only a few units	No evidence of reasoning and problem solving in any units
Use and connect mathematical representations	Curricular language emphasizes draw connections between mathematical concepts and representations in all units	Curricula language emphasizes connections between mathematical concepts and representations in most units	Curricula language emphasizes connections between mathematical concepts and representations in few units	No evidence of language emphasizing connections between mathematical concepts and representations.
Facilitate meaningful mathematical discourse	Explicit emphasis on mathematical discourse in all units	An emphasis on mathematical discourse can be implied throughout the curricula	Mathematical discourse is addressed only in a few units	No evidence of mathematical discourse
Pose purposeful questions	Comprehensive questions are used to guide the unit and questioning strategies are emphasized throughout the curricula	Comprehensive questions are used to guide the unit or questioning strategies are emphasized throughout the curricula	Questioning strategies are referenced in some units	No evidence of purposeful questioning
Build procedural fluency from conceptual understanding	Emphasis on conceptual understanding as the foundation of each unit.	Conceptual understanding is the foundation of some units, while others focus on procedural fluency.	Most units focus on procedural fluency, with the occasional influence of conceptual understanding	All units are procedural fluency focused.
Support productive struggle in learning mathematics	A continuum of rigorous material is evident in all units	Rigorous material is evident in some of the units	Rigorous material is rarely evident in units	Rigorous material is not evident at all and will not result in a productive struggle

Elicit and use evidence of student thinking	Emphasis on strategies that promote the use of student thinking to further class wide understanding in all units– specifics are provided	Emphasis on strategies that promote the use of student thinking to further class wide understanding in most units – specifics are provided	Emphasis on strategies that promote the use of student thinking to further class wide understanding is vague and evident in a few units	No evidence of strategies to promote the use of student thinking to further class wide understanding

Similarly, the NCTM *Effective Mathematics Teaching Practices* was the standard by which I analyzed the effectiveness of the curricular resources to facilitate best practices in mathematics instruction. If the written curriculum is the blue print for each course, the curricular resources/textbook strongly influences the day to day lesson planning. Consequently, an effectively written curriculum guide can be derailed by a textbook that is not appropriately aligned. Textbooks play a prominent role in guiding teacher instruction and often become the curriculum, therefore it is important to determine whether Hardin's resources provide teachers with a solid instructional base (Banilower, McMahon, & Smith, 2001; Reys & Reys, 2006).

A similar rubric system was used to evaluate the district's textbook for 7th and 8th grade math (figure 2). However, the specifics of the rubric were changed to more appropriately mirror the specificity a textbook can offer; meaning, that the textbook can specifically address areas in the NCTM document with greater depth than a curriculum guide. The last best practice, *elicit and use evidence of student thinking*, is not applicable. The textbook is not scripted and does not offer suggestions on strategies to use during whole group instruction. It can be inferred that the material within the textbook can be used to elicit and use evidence of student thinking, but it would depend on teacher choices. The rubric contained a 0 to 3 scale and a mean score of two was the standard for determining the textbook's propensity for positioning Hardin's teachers as capable of implementing the aforementioned best practices.

The textbook is organized with a standard outline for each lesson. Each lesson includes base level instruction and vocabulary, examples with scaffolded instruction, *quick checks* and checks for understanding, *standards practice,* multiple choice practice and mixed review, and mathematical reasoning. There are also unit readiness assessments, lesson objectives, a section for differentiated instruction, extra practice problems, and unit assessments. These sections were analyzed to determine how effectively they promote the NCTM teacher practices.

Figure 3

Effective Mathematics Teaching Practices	**3**	**2**	**1**	**0**
Establish mathematics goals to focus learning	Clear and specific math related learning goals	Vague or generic math related learning goals	Learning goals unrelated to math	Absence of learning goals
Implement tasks that promote reasoning and problem solving	All lessons directly reference mathematical reasoning and problem solving with multiple entry points and varied solution strategies	All chapters contain sections for mathematical reasoning and problem solving with multiple entry points and varied solution strategies	All chapters contain sections for mathematical reasoning or problem solving with multiple entry points and varied solution strategies	No evidence of mathematical reasoning or problem solving with multiple entry points and varied solution strategies.
Use and connect mathematical representations	All chapters include instructional aids that promote students making connections between mathematical representations	Some chapters include instructional aids that promote students making connections between mathematical representations	Few chapters include instructional aids that promote students making connections between mathematical representations	No evidence of instructional aids that promote students making connections between mathematical representations
Facilitate meaningful mathematical discourse	Explicit emphasis on mathematical discourse within all lessons	An emphasis on mathematical discourse appears within each chapter	Mathematical discourse is evident sporadically in only certain sections of the textbook	No evidence of mathematical discourse
Pose purposeful questions	Each lesson poses purposeful math questions intended to build student reasoning and sense making	Evident within each chapter are purposeful math questions intended to build student reasoning and sense making	Purposeful math questions intended to build student reasoning and sense making are evident sporadically throughout the textbook	No evidence of questions intended to build student reasoning and sense making
Build procedural fluency from conceptual understanding	Each lesson focuses on developing a conceptual understanding or uses a previously developed conceptual understanding to build procedural fluency	Each chapter contains lesson(s) that develop a conceptual understanding, some lessons that build on that conceptual understanding, and then others that focus on procedural fluency in a vacuum	There is evidence of developing conceptual understand to build procedural fluency, but is sporadic and non-systematic	No evidence of building procedural fluency from conceptual understanding
Support productive struggle in learning mathematics	A continuum of rigorous material is systematically utilized	A continuum of rigorous material is systematically utilized	A continuum of rigorous material is utilized sporadically throughout the text to	No evidence of supporting productive struggle in learning mathematics

	to support productive struggle in all lesson	to support productive struggle in all chapters	occasionally support productive struggle in all chapters	
Elicit and use evidence of student thinking	N/A	N/A	N/A	N/A

Results

After reviewing the written curricula and textbook, it is evident that they only vaguely or generically facilitate the NCTM *Effective Mathematics Teaching Practices.* As evident in figure 3, the mean score on the rubric for the written curriculum 1.25 and for the textbook 1.29. The highest scores were given to the establishment of math goals (2 & 3), the implementation of tasks that promote reasoning and problem solving (2), and use and connect mathematical representations. The following sections detail how both the written curriculum and curricular resources effectively facilitated the NCTM's *Effective Mathematics Teaching Practices.*

Figure 4

Effective Mathematics Teaching Practices	***Written Curriculum Score***	***Textbook Score***
Establish mathematics goals to focus learning	***2***	***3***
Implement tasks that promote reasoning and problem solving	***2***	***1***
Use and connect mathematical representations	***1***	***2***
Facilitate meaningful mathematical discourse	***1***	***0***
Pose purposeful questions	***1***	***1***
Build procedural fluency from conceptual understanding	***1***	***1***
Support productive struggle in learning mathematics	***1***	***1***
Elicit and use evidence of student thinking	***1***	***N/A***
Mean Score	***1.25***	***1.29***

Establish mathematics goals to focus learning

When evaluating the curriculum documents as a whole, math related goals were found in the *Math Mission Statement, Rationale, Program Goals,* and *Essential Course*

Outcomes. The *Math Mission Statement* made reference to transforming students into "effective problem solvers" and to creating opportunities for students to "explore and communicate mathematical ideas." Similarly, the curriculum rationale makes reference to students becoming "informed problem solvers" and specifically about how they will find the connection between problem solving and real world contexts. These references illustrate the type of math learning the district expects for both teachers and students. However, the other aspects of the mission statement and rationale were generic phrases about learning e.g. "contributing societal members" and "life-long learners." The sections specifically about *program goals* and *essential course outcomes* were lists of generic math topics or skills directly derived from the standards. The goals listed in the curriculum document were too generic to focus learning, were not situated within the learning progression, could not easily be used to make instructional decisions, or were written as a title to a unit, rather than a goal for instruction. The continued references to students as problem solvers did contribute to a score of two.

The textbook contains two sections focused on math learning goals, "*What you'll learn*" and "*And why*." The "*What you'll learn*" section describes to students exactly what they should be able to do by the end of the lesson – it is skill and processed oriented. This section situates students in the learning for the day. It also allows students to assess their progress. The "And why" section provides purpose for the lesson. Students are able to see what they are learning and how it connects to the larger instructional continuum. These two sections provide clear math goals for what students should accomplish within a lesson and how it connects to the larger unit. The strength of these goals can be debated, but the presence of goals gives teachers a launching point and an opportunity to improve or refine pre-existing goals.

Implement tasks that promote reasoning and problem solving

Within the curriculum document there is a section for instructional methods or strategies. Nine strategies are written into the document and none of them specifically address reasoning or problem solving. However, it can be inferred that *identifying similarities and differences* or *generating and testing a hypothesis* require students to reason. Similarly, when evaluating the language in the *learning activity* section, problem solving was not evident, but activities did emphasize student reasoning. For example, there was language which referenced finding patterns, determining relationships, selecting appropriate tools, graphs, equations, etc. given a context, and illustrating how a concept effects another. It can be implied that these activities require student reasoning.

Textbooks have a variety of reasoning and problem solving opportunities, but this particular Prentice Hall Mathematics resource falls short of providing adequate problem solving tasks. Key elements to this best practice are tasks that contain multiple entry points and varied solution strategies. The majority of the tasks are process/procedural based questions aligned to the introduction examples. Each lesson contains *Standards Practice* and *Multiple Choice Practice and Mixed Review* and each unit contains an *Activity Lab, Guided Problem Solving*¸ and *Mathematical Reasoning.* The authors emphasize, in the introduction to the textbook, that these sections are intended to mirror the procedural instruction at the outset of the lesson and for students to apply what they have learned. The questions are mostly depth of knowledge level 1 or 2. Even the sections labeled as problem solving, simply walk students through a series of steps for solving a particular problem. The questions and tasks present in the text do not contain multiple entry points, nor are there variable solution strategies. There is a level of mathematical reasoning that is expected with the *Challenge* problem, *Advanced Leaner* differentiated section, and the *Mathematical Reasoning* section, but it is sporadic throughout the unit and not a focus of the textbook overall.

Use and connect mathematical representations

In reading the curriculum documents, it was difficult to recognize how teachers were using and connecting mathematical representations. There were examples throughout the *learning activities* sections that made reference to "illustrating using various grouping methods," "construct models," or "comparing models." I implied that teachers would use these activities to draw connections and use connections between representations to deepen student understanding, however this sentiment is not explicit. The example that fits this teaching practice the best was, "use several different models to illustrate the possible outcomes." However, this type of language is infrequent and is not a priority within the curriculum.

Facilitate meaningful mathematical discourse

Mathematical discourse was not only a part of the NCTM teacher practices, but was a prominent theme throughout research. However, it was not a prominent component of the written curriculum. In the section detailing instructional strategies there is no reference to mathematical discourse or even more vaguely, whole group discussion. It can be implied that cooperative learning requires student discussion, but there are no specifics as to how discourse would be used to drive instruction. Similarly, the only time discussion/discourse appears in the curriculum guide explicitly is in phrases like "discuss how to," followed by a concept. These phrases are more objectives for the teachers to follow, than a means to spark meaningful student discourse. If this curriculum is followed as written, mathematical discourse would be almost non-existent.

Similarly, to the curriculum documents, the textbook does not emphasize student discourse. There is no mention throughout the lessons, or units at large, that specifically dictate teachers to hold conversations or explore concepts through discourse. As students are being exposed to examples problems there are no prompts for them to discuss as a class. There is no indication that student to student interaction or conversation is an important tenant of the text's vision for learning. If discourse were to be a part of math classrooms at Hardin Middle, it would come from the teacher's own invention. A highly effective teacher could infuse discourse into this curricular resource, but mathematical discourse is emphasized almost nowhere in the text.

Pose purposeful questions

Questioning is not a significant portion of the written curriculum. One of the instructional methods is listed as "cues, questions, and advanced organizers." None of the 7th grade units selected that instructional strategy and while it is generically listed in all of the 8th grade units, there are no specific questioning strategies listed, no reference to how teachers are to use questioning strategies, nor any examples of questions that apply to a specific topic. There are also no *essential* or guiding questions for students to ponder and ultimately address throughout the unit. Teachers may be expected to pose questions, but the curriculum documents are an insufficient guide.

The textbook has a limited emphasis on purposeful questioning or the utilization of questioning strategies. As new material is introduced, there are no guiding questions to prompt student thinking or help students make connections between new and previous learning. In the teacher edition, there are no questions for assisting teachers in facilitating: discussion, sense making, or student misconceptions. As students are working through the initial examples, there are checks for understanding, but these are problem sets that mirror the examples. The only systematic questioning tool is found in the teacher edition under the section *Closure*. Within the section teachers are prompted to ask a question about what students learned and how they can represent their learning during the summary. While some of these questions are purposeful and address sense making, questioning is too infrequent and minimized as a strategy.

Build procedural fluency from conceptual understanding

Over fifty unit guides make up the written curriculum for both 7^{th} and 8^{th} grade. Within the guides there are less than five learning activities or objectives that directly reference developing a conceptual understanding (e.g. students derive the formula for area of a circle). The remainder of the objectives focus on procedural learning. The 8^{th} grade curriculum references real-world problem solving that could lend itself to developing a conceptual understanding, especially if problem-based learning models were used. However, this again requires the teacher to imply that building a conceptual understanding is paramount – it is not explicit or prevalent within the curriculum.

The textbook's primary focus is procedural fluency through direct instruction – conceptual understanding is almost a nonfactor. All lessons follow the same format to create consistency for students. Within that format students are exposed to sample problems through direct instruction, their understanding is assessed through problems that mirror examples, and then students practice the skill through leveled problems.

During the introduction of new material, the explanations are process oriented, detailing what students should do first, second, etc. Within those explanations, the textbook, where applicable, will give the reasoning as to why the process is carried out. For example, during a lesson about solving equations, the textbook directs students to subtract a six and then states because of the inverse property of addition. While this reasoning is helpful for student mastery, it is not the same as building a conceptual understanding of an equation or the properties of inverse operations. Simply being told why, is not the same as developing an understanding of why.

Support productive struggle in learning mathematics

Within the rubric, a productive struggle is evident through a continuum of rigor. All students should experience a productive struggle, which requires evidence of scaffolding e.g. remediation and extension. While there are direct references to *enrichment* and *correction exercises,* these sections are not descriptive nor are they crafted to emphasize a productive struggle at all levels. Creating an environment for a productive struggle is a proactive decision in curriculum writing, however, the sections that address scaffolding for students are reactive. Also when examining the *learning activities*, it was clear that the verbs denoted a lower level on Bloom's hierarchy. For the most part, the activities listed were not rigorous and lived in the knowledge, comprehension, and application tiers. Without rigor evident in the curriculum documents, there will not be an intentional productive struggle for most students.

A significant portion of the teacher edition emphasizes differentiated instruction. The text outlines three sections: *Below Level, On Level*, and *Advanced.* The introduction to the textbook displays a chart with how often these differentiation levels are listed throughout the unit, 89% of lessons have an *Advanced* component and 93% have a *Below Level* component. This is significant because a focus on differentiated instruction can assist in providing all students with an opportunity for a productive struggle. Yet, when dissecting the resource these sections are only available in the teacher edition and only apply to a small portion of the lesson. Each differentiated instruction section consists of either one question/task or one idea to address a component of a student's misconception. The tasks and problems embedded in the practice sections are "leveled", but do not provide an opportunity for productive struggle as students deepen their knowledge of a concept. The problems sets are predominantly compiled of lower DOK tasks, which would inhibit a productive struggle for most on level and advanced students.

Elicit and use evidence of student thinking

Equivalent to purposeful questioning, the curriculum document lists *cooperative learning* as an instructional strategy, but gives no specific about how to implement this strategy. Cooperative learning could be an effective strategy to elicit and use student thinking to make connections, provide whole group instruction, create an opportunity for discourse, push students to model their thinking, etc. Yet, there are no specifics to assist teachers in knowing how to use this strategy within a unit and thus the researcher could not give the curriculum document a higher score than a one. For the score to increase, evidence of student modeling, the use of strong/weak student work, summarizing strategies that emphasized the use of student thinking, or activities that at minimum discuss student knowledge would need to be present.

Nowhere in the textbook does it dictate that teachers should display or utilize student thinking in providing instruction or summarizing content. Although it can be implied that as teachers discuss examples or practice problem with their class, they could leverage student thinking. This is a customary practice, but nonetheless is not discussed in the book. Given the commonality of the practice, but lack of explicit emphasis, the researcher chose to leave this practice out of the textbook's evaluation.

Discussion and Recommendations

Given the district's written curriculum and the accompanying curriculum resources lack of alignment with NCTM's best practices, the district must correct course. While a significant portion of curriculum is how it is implemented by teachers, expecting teachers to implement best practices with a curriculum that does not facilitate them is problematic. While this curriculum does not prohibit a teacher from developing their instruction in a way that facilitates the NCTM effective teaching practices, it can be improved to more explicitly feature them. Similarly, it is imperative that the curriculum is rewritten to reflect the instructional practices supported by research. Similarly, the district should adopt curricular resources that support the rewritten curriculum. State testing achievement in the district is significantly lower than the rest of St. Charles County school district and only modestly above the state average. The impetus is evident for improving student achievement; and addressing curriculum and its accompanying resources is the initial step. The district has a process for convening grade level teachers to rewrite curriculum, the following are recommendations.

I. Align curriculum to current Missouri Learning Standards

II. Determine priority standards to drive the development of the curriculum.

III. Create a standards aligned curriculum utilizing an *Understanding by Design* curriculum structure.

IV. Select new curricular resources aligned with the written curriculum and best practices

V. Provide professional development aimed at connecting the available research on best practices and the curricular resources implemented in the classrooms.

The district's curriculum is not aligned to current grade level standards; Missouri released new standards in 2016. A lack of alignment presents numerous problems. Primarily, the state assessments were rewritten to reflect the new Missouri Learning Standards in 2017, if teachers have not adjusted their instruction, students will not be successful on the MAP or EOC. A lack of alignment creates an exponential gap in student learning. While individual teachers may have adjusted their instruction, the district has not made a systemic shift to align curriculum with new state standards. As curriculum is rewritten, the district must use the most current grade level standards and implement a process for updating curriculum immediately following the release of new grade level standards.

Researchers argue that quality curriculum has a narrow focus in topics for students to gain a deeper conceptual understanding of the material (Hook, Bishop, Hook, 2007). Teachers are also restrained by timelines. School years have a fixed number of days and given professional development schedules, field trips, district wide assessment programs, the invariability of student attendance, and state testing windows, instructional time is limited. Consequently, it isn't realistic to believe that students can meet the conceptual expectations of current grade level standards, be assessed on their understanding, have instruction geared towards addressing areas of weakness, and then have an opportunity to show mastery on reassessment, if all standards within a grade level are covered equally. The framework the district must adopt is *depth over breadth*.

By implementing a priority standard model before curriculum writing, teachers are able to focus their instruction and curriculum development on the most foundational topics within their grade level standards (Kilpatrick et al., 2001). Ainsworth defines priority standards as, “a carefully selected subset of the total list of the grade-specific and course-specific standards within each content area that students must know and be able to do by the end of each school year in order to be prepared for the standards at the next grade level or course” (2013). The district will need to utilize the content knowledge available within their math departments and DESE released blueprints to dissect which standards are the most substantial within each grade level.

A secondary component to the priority standard model is vertical alignment. For a standard to be a priority standard it must prepare students for the next grade level’s content expectations (National Math Advisory Panel (NMAP), 2008). Consequently, teachers within the middle school must engage in conversations with the secondary level math teachers to determine which standards are both integral to the 7/8 curriculum and are foundational for success in Algebra 1. This vertical alignment only strengthens the district’s curriculum and ensures that redundancies are kept to a minimum, prerequisite skills are intentionally covered, and students are able to progress through math classrooms that build on prior learning.

Designing the new curriculum with an *Understanding by Design* (UbD) model will ensure that the curriculum is aligned to the standards. A UbD structure functions utilizing backwards design. Curriculum writers begin with the desired results (grade level standards), shift towards determining acceptable evidence (assessment), and then plan learning and activities and instruction (Wiggins & McTighe, 2005). This type of structure would ensure that SCSD teachers are beginning with state standards and ensuring the curriculum is aligned. Within the larger UbD framework are curriculum templates derived from Wiggins and McTighe's research (Appendix B). The template requires curriculum writers to formulate their priority standards into units each containing a *Big Idea*, *Enduring Understandings*, *Essential Questions*, and learning targets (Wiggins & McTighe, 2005). A *Big Idea* is a core concept or theory that will drive curriculum development and instruction (Wiggins & McTighe, 2005). A unit's *Big Idea* will guide the discovery, discourse, and modeling within a unit (Wiggins & McTighe, 2005). *Enduring Understandings* summarizing integral concepts and ideas that are not only significant to the unit itself, but important to learning beyond the particular unit (Wiggins & McTighe, 2005). *Essential Questions* are intended to connect learning to a real-world context, peak student curiosity, and help foster a culture of discovery which lead students to understanding the key concepts within the unit (Wiggins & McTighe, 2005). Pushing teachers to develop *Big Ideas*, *Enduring Understandings*, and *Essential Questions* will assist in ensuring that a conceptual proficiency of math topics is a focal point of the curriculum. With a conceptual foundation flows an opportunity to emphasize the other seven effective teaching practices.

Each priority standard will drive unit development, requiring that teachers narrow their grade level standards to a reasonable five to seven priority standards. Units will also include supporting standards. Supporting standards are "those standards that support, connect to, or enhance the Priority Standards" (Ainsworth, 2013, xv). These standards are not assessed as in depth and are utilized as scaffolding to assist in the mastery of the more rigorous and comprehensive priority standard. If grade level standards do not support the mastery of priority standards, then they are deemphasized and likely not covered. This framework not only minimizes the content teachers are required to cover, but facilitates the careful embedding and organization of standards for increasing student mastery.

The district will need new curriculum materials. To choose those materials correctly, the curriculum decision-makers must ensure that they use an evaluation tool aligned with the newly written curriculum and best practices in mathematics. The evaluation tools must be designed before curricular resource options are presented to prevent bias and to guarantee that the product chosen is selected because of its ability to facilitate the written curriculum and what research implies increases student achievement. A quick Google search will reveal numerous evaluation tools that the district can modify to meet their needs.

While the new curriculum has not been written and many resources may align, there is one product in particular that connects the NCTM *effective teaching practices* with daily lesson structures, *into Math* published by Houghton Mifflin Harcourt. *into Math* emphasizes building students procedural fluency through conceptual understanding by utilizing what they have coined the *Learning Arc*. Within this model, students progress through units that begin with building a conceptual understanding, transition to connecting concepts and skills to allow for the conceptual and procedural to merge, and then close with application and practice of the procedural skill. According to the website and promotional materials, each lesson attempts to explicitly include each of the NCTM *effective teaching practices*. This is a new product and I was not able to evaluate the curriculum using the same tool I used for the SCSD math curriculum. These claims come primarily from research the curriculum through the *into Math* website.

When choosing a quality curricular text, companies will often offer professional development to aid in the implementation of the program. The district should take advantage of any textbook company's professional development program to ensure that the tenants of the curricular resources are executed with fidelity and credibility. However, this type of professional development does not necessarily address general best practices in mathematics instruction. There must be a bridge forged between the learning necessary to masterfully execute the curricular resources and what research states are best practices in the field. Professional development is the means by which curriculum becomes evident within classrooms (Taylor, 2016).

The curriculum and instruction department will need to evaluate the professional development offered by the textbook company and identify gaps. Once those gaps are identified, the department must determine how to adequately provide development to the staff to ensure that instruction is mirroring best practices. The district has a professional development committee and will convene a curriculum committee during a rewrite. Both committees have a budget and those funds can be used to bring in math instructional experts or provide substitutes for district provided development. Regardless of the course of action, rewriting curriculum and adopting a new curricular resource alone, will not necessarily result in improved instruction. Teachers need development on how to implement the newly written curriculum and textbook as well as how to integrate best practices, or achievement will continue to lag behind the rest of St. Charles County.

Conclusion

Neither the written curriculum, nor the textbook by Prentice Hall are effective tools in facilitating NCTM's effective teaching practices. Consequently, Hardin Middle is lacking a systemic set of instructional tools and resources to implement best practices in math instruction. Without a curriculum rewrite, an adoption of a new textbook or textbook like resource, and professional development to connect the new curriculum to best practices, students will continue to underperform. While these recommendations will likely improve math instruction, there are numerous other conclusions and recommendations that could from a full scale analysis of math instruction with SCSD. The department of curriculum and instruction should convene a team to analyze math instruction K-12. Research specifically about the type of instruction students are receiving is likely to illuminate the reasoning behind a history of mediocre math performance.

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Appendix A

Attached City of St. Charles School District 5-8 mathematics curriculum.

Appendix B

Stage 1 – Desired Results

Established Goal(s)/Content Standard(s): •What relevant goals will this design address? [Comes from professional standards in your field]

Understanding (s) Students will understand that: • What are the big ideas? [This is a goal, not an objective. List the big ideas or concepts that you want them to come away with, not facts that they must know] • What specific understandings about them are desired? • What misunderstandings are predictable?	**Essential Question(s):** • What provocative questions will foster inquiry, understanding, and transfer the learning? [What leading questions can you ask of students to get them to understand the Big Ideas? Address the heart of the discipline, are framed to provoke and sustain students interest; unit questions usually have no one obvious "right" answer]

Student objectives (outcomes): Students will be able to: • What key knowledge and skills will students acquire as a result of this unit? [These are observable, measurable outcomes that students should be able to demonstrate and that you can assess. Your assessment evidence in Stage 2 must show how you will assess these.] • What should they eventually be able to do as a result of such knowledge and skill? [Your learning activities in Stage 3 must be designed and directly linked to having students be able to achieve the understandings, answer the essential questions, and demonstrate the desired outcomes]

Stage 2 – Assessment Evidence

Performance Task(s): • Through what authentic performance task(s) will students demonstrate the desired understandings? [Authentic, performance based tasks that have students apply what they have learned and demonstrate their understanding. Designed at least at the application level or higher on Bloom's Taxonomy.] • By what criteria will "performances of understanding"	**Other Evidence:** • Through what other evidence will students demonstrate achievement of the desired results? [Includes pre-assessment, formative assessment, and summative assessment evidence. Can be individual or group based. Can include informal methods such as thumbs up, thumbs down, and formal assessments, such as quiz, answers to questions on a

be judged? [Rubrics can be used to guide students in self-assessment of their performance]	worksheet, written reflection, essay]

Stage 3 – Learning Plan

Learning Activities: [This is the core of your lesson plan and includes a listing describing briefly (easy to follow)] • W= Where the unit is going? • H= Hook and hold interest • E= Equip all students • R= Rethink and Revise their understanding • E= Evaluate their work • T= Tailored learning (personalization to needs) • O= Organized to maximize engagement