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Academic Rigor for All: A Research Report

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Virginia Commonwealth University
Metropolitan Educational Research Consortium

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ACADEMIC RIGOR FOR ALL: A RESEARCH REPORT

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Executive Summary

Literature Review on Rigor and Findings

Literature Review

Rigor can be defined in any number of ways. We found an imbalance between the ways in which rigor has been defined by the Virginia Department of Education, and how education scholars define rigor in the respective academic disciplines.

- ◆ *The Commonwealth of Virginia* defines rigor as college and career readiness as measured by attendance in post-secondary educational institution, achievement of high Standards of Learning (SOL) test scores, as well as participation in Advanced Placement and International Baccalaureate programs.
- ◆ *Educational Psychologists* tend to define rigor in ways that are generalizable across contexts. Researchers in this tradition focus on *academic press*, or the extent to which educational stakeholders, including students, are oriented towards demanding coursework. Studies in this tradition have also found that student motivation is crucial, and that this motivation is mediated by the extent to which tasks are challenging, related to the world outside of school, and provide opportunities for students to collaborate when problem solving.
- ◆ *Discipline-Based Scholars of Teaching and Learning* define rigor in ways that reflect the core concepts of their discipline. Thus, a rigorous math class is one where students are encouraged to think mathematically, i.e. to use mathematical approaches to solve problems. Although specific pedagogical styles are discussed in this literature, the overall emphasis is on depth rather than breadth, with curricula being designed around building understanding of key concepts rather than covering (or efficiently delivering) factual

information and procedural steps. In other words, a US history course might be organized around the way that the idea of freedom developed over the course of US history.

Findings

- ◆ Findings indicate that rigor is closely related to the concept of the *zone of proximal development*. Teachers who are effective at implementing rigorous instruction seek to challenge their students at a level that will not go beyond their abilities. Thus, rigor will look different in different schools where students' academic needs are different. Rigor will also look different among the same students at different points in the year. As students become accustomed to teacher expectations, teachers are able to demand more from them. Time is a key element in this progress.
- ◆ All students are capable of meeting the rigorous requirements of their teachers if teachers are able to set the level of rigor in a way that meets students' needs.
- ◆ Teachers who organize their instruction around concepts that are recur in a unit or across the academic year are more successful, even with the most challenging students.

Background

Accountability as a Policy Context

Since the publication of *A Nation at Risk* in 1983, policy makers at the state and federal level have sought to improve the rigor of instruction and achievement of American K-12 students (Hamilton, 2003; Hess, 2003; Ravitch, 2010). The most popular of the reforms that has emerged

since *A Nation at Risk* (1983) is what scholars call *high-stakes*, or *test-based accountability*¹. Over the past three decades, policy makers have coalesced around the idea that the root cause of our nation's (supposed) educational decline is a lack of accountability (Hess, 2003; Loveless, 2005). As Loveless (2005) articulates it,

The standards and accountability movement is based on the theory that a sequence of three activities will improve education: first, defining what students should learn (setting standards); second, testing to see what students have learned (measuring achievement); third, making the results count (holding educators and students accountable). (p. 7)

Education historian Larry Cuban (2005) listed a set of assumptions that underlie the theory articulated by Loveless (2005). Cuban (2005) writes that these assumptions include that:

- ◆ Strong economic growth, high productivity, long-term prosperity, including a higher standard of living, and increased global competitiveness depend upon a highly skilled workforce.
- ◆ Public schools are responsible for equipping students with the necessary knowledge and skills to compete in an information-based workplace.
- ◆ Public schools are doing a poor job of preparing high school graduates for college and the workplace, with urban schools doing the worst job of all.
- ◆ Schools are just like businesses. The principles that have made businesses successful can be applied to schools to produce structural changes that will improve academic achievement as measured by standardized tests, end the skills mismatch, and increase public confidence in schools.
- ◆ Higher test scores in school mean future employees will perform better in college and in the workplace. (pp. 39-40)

The assumptions and theory of action laid out by

Loveless (2005), a supporter of these policies, and Cuban (2005), a critic, have proved enduringly popular with law makers. Politicians and policy makers are responding to what they perceive is the public's demand for improved educational rigor. Studies touting evidence of the successes and failures of accountability policies have filled the pages of a wide range of education journals, and it is difficult to distill a conclusion regarding their overall effects. One recent meta-analysis of the research on the effects of test-based accountability policy over the past two decades concluded that

since 1992, the era of test-based accountability has been associated with increasing student achievement, but improvements have not been as clear-cut or dramatic as had been hoped and cannot be attributed solely to accountability policies. Although the trend continues to be positive, the intensification of pressures since NCLB has not produced commensurately higher gains. (Shepard, Hanaway, & Baker, 2009, p. 2)

Although it is possible that the pressure produced by NCLB has not produced the desired gains, education administrators are faced with important decisions, often prescribed by law, and have little time to use research as an aid in decision making. District administrators are accountable to the public they serve, members of which may share the assumptions about education articulated by Cuban (2005). Chief among these assumptions is one that emerged in 1983 in *A Nation at Risk*, the fear that America is losing ground to economic competitors, and that public schools are responsible for this shift. Policy makers have tried to address this fear by enacting accountability policies that are designed to enhance the value of educational credentials. Writing standards and measuring achievement with tests is supposed to signal to employers that a high-school graduate has a set of cognitive skills that he or she can put to use as a member of the workforce. Doubts, however, remain in the business community about the extent to which

students graduate from high school with the skills that they need to be successful (Hess, 2008). Colleges also continue to have to invest in re-educating freshmen and sophomores so that they have the academic skills to be successful (Nguyen, Bibo, & Engle, 2012).

After a substantial investment of time, effort, and money in testing systems (Chingos, 2012) administrators are asking whether classroom teaching and learning has the rigor to support the building of valued academic skills. A recent report by the Scholastic and the Bill and Melinda Gates Foundation (2012) indicates that teachers across the country do not believe that testing systems have increased academic rigor. The study found that teacher support for standardized testing is very low across the country. For example, “only 26% of teachers say that the results of standardized tests are an accurate reflection of student achievement” (Gates Foundation, 2012, p. 29). Almost half of the teachers surveyed (45%) reported that students do not take standardized tests seriously, nor do they perform to the best of their ability on them (Gates Foundation, 2012). In addition, only 20% of high school teachers surveyed believed that district-level tests were “absolutely essential or very important in measuring student achievement” (Gates Foundation, 2012, p. 27). In contrast, 92% of the teachers who participated in this study reported that measures of achievement, such as formative and ongoing classroom assessments are “absolutely essential” or “very important” (Gates Foundation, 2012, p. 26). What is not known, however, is the extent to which these reported classroom practices support the research community’s definition of rigorous instruction.

There have been attempts at meta-analytical studies of the effects of high-stakes testing policies that rely on various kinds of evidence. For example, two meta-analyses of research on the effects of high-stakes assessment on rigorous

practices were produced in the area of social-studies education (Au, 2007; Grant & Salinas, 2008). These meta-analyses, however, highlight the difficulty of making a definitive statement about the effects of these policies on classroom rigor. Nevertheless, both analyses agree that the evidence from a wide variety of research reports suggests that accountability has not delivered on its promise of greater rigor in history/social studies classes (see also, Grant, 2006; 2003). Au (2007) interprets the overall effect as one in which teaching is more narrowly focused on exam achievement leading to an “increase in teacher-centered instruction associated with lecture and the direct transmission of test-related facts” (p. 263) rather than a more rigorous approach. Grant and Salinas (2008) were more circumspect in their conclusions about the effects of current accountability policies on the climate of rigor in schools, emphasizing the great variability in how district leaders, administrators and teachers have interpreted and acted upon these policies.

Academic Rigor Definitions and Practices

In this literature review, we will attempt to address the issue of academic rigor in several ways. First, we will review federal and Virginia policy documents that discuss academic rigor, and the research reports that influenced these documents. We will then attempt to articulate a clear definition of academic rigor that applies across academic contexts. This definition draws on the work of educational psychologists, sociologists, and scholars of teaching and learning. Finally we will review the research literature on rigorous classroom practice in two disciplines, history and mathematics.

Virginia’s department of education defines rigor

Rigorous instruction is the term used frequently to describe the goals for teachers and students in

documents which seek to influence educational policy in Virginia. The state has defined and discussed the issue of academic rigor in several official state documents (Commonwealth of Virginia Board of Education [CVBE], 2011; Virginia Department of Education [VDOE] 2011; 2010a; 2010b). These documents, in turn, cite two key reports as sources for how rigor is defined and framed (ACT, 2007; International Center for Leadership in Education [ICLE], 2011). These sources define rigor as the quality of the high school curriculum (ACT, 2007), and specify that a rigorous curriculum promotes in-depth learning and the use of cognitive skills similar to those found in the higher-order thinking levels of Bloom's Taxonomy (e.g, application, evaluation, synthesis) (ICLE, 2011). Although the VDOE's definition of rigor is drawn from these reports, state documents rely on measures, such as exam scores and advanced courses taken, as well as participation in post-secondary education as indicators of the existence of rigorous instruction (VDOE, 2011; 2010a; 2010b).

In a number of Virginia Department of Education documents, measures of student achievement are used as evidence to indicate the existence of instructional rigor in schools (VDOE 2010a, 2010b, 2011). These measures include student attainment of advanced *proficient* level—defined as achievement above a particular cut-score on a Standards of Learning (SOL) exam, attainment of college-ready SAT or ACT scores, participation in Advanced Placement, International Baccalaureate, dual-enrollment courses, and participation in the Virginia Early College Scholars program (Virginia Department of Education 2010a, 2010b, 2011). Virginia policy also refers to achievement on NAEP assessments as an indicator of rigor (VDOE, 2011). Virginia students' NAEP scores have remained slightly higher than the national average, but have not risen or dropped significantly since 1998 (National Center for Educational Statistics [NCES], 2011; Schmidt, 2012). The VDOE has not based claims

on the existence of rigor only on the measures mentioned above. The VDOE has publicly committed itself to the preparation of young Virginians for post-secondary education and the world of work (VDOE, 2010a; 2010b). In both the VDOE's "College and Career Readiness Initiative" (2010a) and "Summary of Virginia's Race to the Top Competitive Application" (2010b), rigor is defined in relation to students' post-secondary success. By these measures, Virginia students are succeeding. In the latest report by the Federal Graduation Indicator (FGI), which followed Virginia's graduating class of 2011, 62% of graduates who held standard or advanced diplomas were enrolled in post-secondary education within sixteen months of graduation (VDOE, 2012).

While the number of students enrolling in post-secondary education after high school graduation may serve as an indicator of rigor of the Virginia public school curriculum, questions have emerged about the extent to which high-school graduates are prepared for college-level work. For example, Virginia Commonwealth University's *University College* was founded in 2006 after administrators realized that incoming freshmen, particularly minority students, needed greater academic support in order to succeed during the first years of college (Nguyen et al., 2012; VCU University College, 2012). Since then, Virginia Commonwealth University has seen graduation rates of African American and Hispanic students rise to approximately the same rate of Caucasian students, around 50% (Nguyen et. al, 2012). The necessity of programs like VCU's University College suggests a need for a greater understanding and push for academic rigor in the PreK-12 curriculum in order to provide students with a stronger foundation of academic skills prior to enrollment in college.

Rigor appears to be a major concern for Virginia's educational policy-makers, as exhibited by the frequency of the term in policy documents

(Commonwealth of Virginia Board of Education, 2011; Virginia Department of Education 2010a, 2010b, 2011). However, its summative definition does little to aid administrators, teachers, parents, and students as they attempt to determine how rigor is manifested in schools. The development of formative definitions for rigor, in conjunction with the existing summative definitions provided by Virginia educational policy, may be useful for educators as they work to increase rigor in Virginia's schools.

Studying rigor

Academic rigor has been studied both quantitatively (e.g. Burris, Wiley, Welner, & Murphy, 2008; Matsumura, Slater, & Crosson, 2008) and qualitatively (e.g. Boston & Wolf, 2006; Bower & Powers, 2009), though most studies of rigor employ post-positivistic methods. Studies of rigor have been conducted with gifted and regular education students, but often focus on schools with low socio-economic status (Burris et al., 2008; Cohen & Poon, 2011; Harris & Harington, 2006; Lee & Smith, 1999). Typically, studies of rigor have been conducted in middle and high schools (Hoy & Hannum, 1997; Lee, Smith, Perry, & Smylie, 1999; MDRC, 2008; Stein, Grover, & Henningsen, 1996; Sweetland & Hoy, 2000; Waring & Robinson, 2010).

Quantitative studies of rigor often employ teacher or student surveys designed to assess the perceived level of rigor in lessons or the school climate as a whole (Matsumura et al., 2008; Phan, 2009; Shouse, 1996; Sweetland & Hoy, 2000). In such studies, student scores on tests of achievement serve as the chief proxy for rigor (Lee & Smith, 1999; Matsumura et al., 2006; Newmann, 1991). Quantitative studies of rigor often seek to reveal a causal relationship between rigor and student achievement (Burris et al., 2008). These methods favor the descriptions and guidelines for rigor presented by ACT (2007) and the Virginia Department of Education (2010 a, b; 2011).

Qualitative studies of rigor typically employ either classroom observation, sometimes combined with interviews (Boston & Wolf, 2006; Cohen & Poon, 2011; Wasley, Hampel, & Clark, 1997), or document analysis in which teacher lesson plans are analyzed for indicators of rigor (Henningsen & Stein, 1997; Hess, Carlock, Jones, & Walkup, 2009; Wolf et al., 2004). Such studies often seek to describe rigorous school and classroom climates, identifying proxies for rigor and how rigor is perceived by teachers and students. These studies often utilize or help to develop criterion-referenced rubrics for rigor which allow researchers and administrators to determine the level of rigor present in lessons or the school climate (Boston & Wolf, 2006; Matusecich, O'Connor, & Hargett, 2009; Mitchell et al., 2005). Proxies for rigor in these studies include high-level classroom discourse and questioning (Bower & Powers, 2009; Matusevich et al., 2009; Wehlage, Newmann, & Secada, 1996;) and lessons which require students to solve problems and make connections (Henningsen & Stein, 1997; Matusevich et al., 2009; Wehlage et al., 1996).

Defining rigor across the disciplines

Rigorous teaching. Academic rigor typically describes curriculum or instruction which holds students to high standards, includes opportunities for the development of connections and deep knowledge, and fosters application of knowledge to real-world problems (Darling-Hammond, 1995; ICLE, 2011; Newmann, 1996). Rigorous teachers exhibit a disposition towards teaching that stresses the demand for great effort or commitment on the part of students to reach a certain standard (Blackburn, 2008; Darling-Hammond, 1995; Newmann, 1996). Teachers with this disposition are primarily concerned with student learning, teach within their students' zone of proximal development, teach their students to think and work in disciplined ways, and provide opportunities for students to connect in-school knowledge to out-of-school knowledge (Newmann, 1996).

Holding high expectations for student learning is at the heart of academic rigor (Bower & Powers, 2009; Darling-Hammond, 1995; Mitchell, Shkolnik, Song, Uekawa, Murphy, Garet, & Means, 2005; Newmann, 1996; 1991). For example, Hoy and Hannum (1997) found that teachers and administrators in over eighty middle schools described academic emphasis as

the extent to which a school is driven by academic excellence. High but achievable goals are set for students, the learning environment is orderly and serious, teachers believe in their students' ability to achieve, and students work hard and respect those who do well academically. (p. 294)

These findings relate to what Hoy and Hannum (1997) describe as *academic press*, a term which was used in many psychological studies in the 1990's and is now synonymous with rigor amongst educational psychologists (Hoy & Hannum, 1997; Lee & Smith, 1999; Lee, Smith, Perry, & Smylie, 1999; Shouse, 1996). Academic press often refers specifically to aspects of the educational or school climate that work in concert to foster high expectations and achievement (Murphy, Weil, Hallinger, & Mitman, 1982). Studies framed by the academic press construct investigate the relationship between academic press and student achievement (Hoy & Hannum, 1997; Lee & Smith, 1999; Lee, Smith, Perry, & Smylie, 1999; McDill, Natriello, & Palas, 1986; Murphy, Weil, Hallinger, & Mitman, 1982; Shouse, 1996), and have been conducted using both quantitative and qualitative methods. Studies such as that of McDill and colleagues (1986) found that student achievement varied systematically with levels of academic press, indicating that academic press and achievement were related.

Similar to Vygotsky's idea of the zone of proximal development (Vygotsky, 1978), rigorous teaching assumes all students can learn if they experience educational activity that is set at an appropriately challenging level and provides time for mastery of new concepts (Blackburn, 2008; Bower & Powers,

2009; Brimfield, 1988; Common Core, 2012; Olvera & Walkup, 2010). Many studies of academic rigor suggest that systems of stratification typically found in secondary education contribute to the deterioration of rigorous education for students tracked in classes deemed to have lower-ability students (Bower & Powers, 2009; Burris, Wiley, Welner, & Murphy, 2008; Reed, 2008; Resnick, 1995, 2001, 2006). Resnick (1995) suggests that this may be due to the prevailing view of intelligence as a fixed property, meaning that students' possess a level of aptitude that does not change over time (see also Dweck, 2000). This leads educators to modify the pedagogical approach, academic press, and cognitive complexity of instruction (i.e. rigor) for their students who have been placed in non-college tracks (Resnick, 1995). For example, when comparing the expectations and practice of two mathematics teachers who taught both honors and regular pre-calculus classes, Reed (2008) found that "tasks become less demanding for the regular students as they are not required to do the same amount of mathematical activity as the honors students" (p. 57).

This dilemma can be remedied by differentiating instruction in order to challenge students at appropriate levels (Blackburn, 2008). Education is still considered rigorous if students are held to expectations that are considered high for the individual. Challenging discourse, connections between prior knowledge and new concepts, and real-world applications help to foster high expectations for all students (Matsumura, Slater, & Crosson, 2008; Newmann, 1991; Newmann, 1996; Stein, Grover, & Henningsen, 1996; Wehlage, Newmann, & Secada, 1996). Building these concepts into instruction allows teachers to address definitions of rigor identified in policy documents as well as the definition of rigor developed by scholars. However, teachers are not solely responsible for increasing the level of rigor in education. Students also play a role in determining the level of rigor of their education.

Students and rigor. Engagement is central to students' participation in a rigorous education (Blackburn, 2008; Brimfield, 1988; Kilpatrick, Swafford, & Findell, 2001; Matsumura, Slater, & Crosson, 2008; MDRC, 2008; Stein & Lane, 1996), and is also increased when students are intrinsically motivated to learn. In their evaluation of educational reform in underprivileged schools in which increased academic emphasis (i.e., rigor) was a central focus of reform, Stein and colleagues (1996) found that student products that reflected high levels of academic rigor were related to students' self-reports of intrinsic motivation to learn. Teachers fostered such motivation by increasing the complexity and real-world relevance of tasks, encouraging students, for example, to develop their own solutions to mathematical problems. Teachers can foster engagement by careful task selection, including tasks that have relevance to students' interests and real-world applications (Blackburn, 2008; Kilpatrick, Swafford, & Findell, 2001; NCTM, 2000; Williamson & Blackburn, 2010). High-level questioning and discourse, along with mixed-ability cooperative groups, can also help to increase student engagement (Matsumura, Slater, & Crosson, 2008; Newmann, 1991; Stein, Grover, & Henningsen, 1996).

In recent years, cognitive psychologists have studied higher-order thinking or critical-thinking skills as related to student achievement (Barak, Ben-Chaim, & Zoller, 2007; Franke, Webb, Chan, Battey, Ing, Freund, & De, 2007; Phan, 2009). Promotion of critical thinking has been linked to academic rigor and includes skills indicative of academic rigor, such as high-level discourse and the application of classroom knowledge to real-world problems (Wolf, Crosson, & Resnick, 2004). Critical or higher-order thinking is defined in these studies as the process of using prior knowledge, reflection, analysis, and synthesis to address new and perplexing, often real-world, problems (Phan, 2009; Seixas, 2006; Waring & Robinson, 2010). Such studies have been conducted both

quantitatively and qualitatively, and often cite classroom discourse and questioning as indicators of critical thinking (Barak et al., 2007; Franke et al., 2007; Kracle, 2012; Waring & Robinson, 2010; Wolf et al., 2004). Education scholars who specialize in particular disciplines, however, tend to have more elaborate definitions of critical thinking that are closely related to the kinds of thinking necessary for that particular discipline. This review investigates how scholars conceptualize rigor more specifically in the math and history disciplines below.

The following two sections take up the issue of rigor as it relates to the specific disciplines of mathematics and history/social studies respectively. In these sections we highlight the findings of scholars from a variety of backgrounds whose studies of academic rigor are framed by the big ideas of a particular discipline. Although some findings are congruent, the studies discussed below differ from those mentioned above. Rather than endeavoring to make universal statements about academic rigor, the scholars discussed below are interested in studying the pedagogical practices that lead students to adopt disciplinary modes of thinking, e.g. thinking mathematically, or historically. These modes of thinking involve understanding key concepts and solving authentic problems.

Rigor in mathematics. In 2001, the National Research Council's (NRC) Mathematics Learning Study Committee, under the sponsorship of the National Science Foundation and the U.S. Department of Education, published a report synthesizing research on mathematics learning. The committee consisted of individuals with diverse backgrounds ranging from school teachers to principals, business executives and university professors. The report, published under the title *Adding It Up* (Kilpatrick et al., 2001), plainly portrayed the changing nature of the meaning of successful mathematics learning in school, and in society at large, throughout the twentieth century. As described in the report, in the first half of the

past century, successful mathematics learning primarily meant gaining facility in using computational procedures within the discipline. Starting from the late 1950s, until the end of the 70s, success in mathematics meant gaining understanding of the structure of the unifying ideas of the discipline. Acquiring the necessary mathematical problem solving skills were also part of the espoused successful learning criteria of these decades. This era, also referred to as the *new math*, came to an end with 1980s emphasis back to accuracy and speed in carrying out the computational procedures in mathematics.

In 1989, the leading national professional organization in mathematics education, the National Council of Teachers of Mathematics (NCTM), published its first of a series of "standards" documents, which started the contemporary reform movement in mathematics education. Combining and synthesizing the goals of the past century, these standards documents (NCTM, 1989, 1991, 1995, 2000) gradually characterized successful mathematics learning as the development of 'mathematical power,' which includes correct and sophisticated mathematical reasoning and communication skills, conceptual understanding of the big ideas of the discipline, knowledge of the necessary procedures and computations, as well as the ability to solve mathematical problems (Kilpatrick et al., 2001; Stanic, 2003). Thus, with the publication of these NCTM standards documents, a growing consensus has been built among mathematics education leaders about the need to define successful mathematics learning to include a wide range of knowledge, understanding, skills and dispositions, rather than a focus on one particular proficiency as was done in the past century.

To help clarify the goals of NCTM's reform movement, NRC's Mathematics Learning Study Committee also offered, in their report *Adding It Up* (Kilpatrick et al., 2001), five proficiency strands

in mathematics that all students should attain at all levels. These proficiency strands are viewed as the pillars of successful mathematics learning today. The five strands are coined as conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

Conceptual understanding refers to a student's grasp of the underlying mathematical concepts and relations. Achievement of understanding involves meaningful activity on the part of the learner, who develops deep and relational understanding of central mathematical concepts. *Procedural fluency* is similar to the goal of facility in quickly and accurately carrying out the computational procedures in mathematics that was espoused in the past. The current conception, however, adds flexibility to efficiency and accuracy, which includes flexibly choosing and using procedures in particular situations based on an understanding of how and why the procedures work. *Strategic competence* involves being able to approach problem situations in a variety of ways and planning and carrying out effective mathematical strategies to solve problems. *Adaptive reasoning* is defined as the ability to persuasively explain one's reasoning while mathematically justifying the solution steps used to arrive at the correct answers. Finally, *productive disposition* is the ability to perceive and appreciate mathematics as sensible, useful, worthwhile and relevant. There is a strong consensus in the field of mathematics education that all of these five proficiencies should be at the center of rigorous teaching in all mathematics classroom across the country. Thus, it is widely agreed that successful learners of mathematics demonstrate strength and power in all of these proficiencies.

As evident in the currently espoused mathematical proficiencies, rigorous mathematics instruction demands that students engage in meaningful mathematical activities that involve

disciplinary reasoning, effective communication, strategic problem solving and fluent computation, and that result in the growth of conceptual understanding (Kilpatrick et al., 2001). To elucidate the basis for each of these tenets of a rigorous mathematics lesson, mathematics education scholars extensively discussed the major theoretical perspectives that guide the recommended pedagogical practices. Cobb's (2007) account of the current major theoretical perspectives in the field of mathematics education, which was published in the National Council of Teachers of Mathematics (NCTM)'s second handbook for research in mathematics education, serves as a useful overview. According to Cobb (2007), four major theoretical perspectives underlie current research and practice in mathematics education: Experimental psychology, cognitive psychology, socio-cultural theory, and distributed cognition theory. In-depth historical origins and more detailed accounts of each perspective can be found in Cobb (2007) and elsewhere.

Similar to research in other disciplines, researches on how mathematics is taught and learned, and suggestions for its improvement, are based on findings from a number of different research communities, including experimental psychology, cognitive psychology. These studies are framed by theories of mind that tend to emphasize the development of individual constructions of mathematical knowledge, or the development of social constructions of mathematical knowledge (Cobb, 2007). As Simon (2009) contends, these different theoretical perspectives should be viewed as complementary sources for educational scholarship and practice. This balance and harmony of theoretical bases in mathematics education underlie the NCTM's widely embraced five process standards: problem solving, reasoning and proof, communication, connections, and representation, which summarize the research-based practices that help increase the aforementioned proficiencies.

It is recommended that these five processes are implemented in every mathematics lesson and become an integral part of mathematical practice in school. Mathematics educators commonly believe that rigorous mathematics instruction that combines challenging content with these mathematical processes on a daily basis has the highest potential to increase the aforementioned proficiencies in all students and thus bring about successful learning for all. The NCTM's (2000) latest standards document describes the five processes as follows:

Problem solving: Instructional programs should enable all students to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; monitor and reflect on the process of mathematical problem solving.

- ◆ *Reasoning and proof:* Instructional programs should enable all students to recognize reasoning and proof as fundamental aspects of mathematics; make and investigate mathematical conjectures; develop and evaluate mathematical arguments and proofs; select and use various types of reasoning and methods of proof.
- ◆ *Communication:* Instructional programs should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; use the language of mathematics to express mathematical ideas precisely.
- ◆ *Connections:* Instructional programs should enable all students to recognize and use connections among mathematical ideas; understand how mathematical ideas

interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics.

- ◆ *Representation*: Instructional programs should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena (NCTM, 2000).

Although today's mathematics classrooms are changing to include these processes, if we look at a typical mathematics classroom across the country, it is still likely to observe a teacher mostly trying to help his or her students carry out a certain solution method or algorithm correctly (Kilpatrick et al., 2001). This method or algorithm is likely to be presented in its entirety at once and demonstrated several times until most students seem to have mastered its correct execution. Similar to the mathematics education practices of the previous century, computation is likely to be the overarching mathematical process, and obtaining right answers to the computations is likely to be considered the manifestation of successful learning. Vis a vis these typical practices, Ball (1991) writes: "When we hear right answers simply as representing understanding, we miss opportunities to gain insight into students' thinking" (p. 45). The ways in which students reason and think about a given mathematical situation are crucial for teachers to know because, based on the theories of mathematical learning outlined earlier, students' existing knowledge and ways of thinking shape their current learning. Even if a student gives a correct answer to a question, the meanings and understandings that the student holds should be known to teachers in order to promote conceptual development (Ball, 1991). To achieve such conceptual development in their students,

teachers should design effective learning environments with carefully chosen tasks and activities, facilitate students' learning by providing suggestions, listening and posing questions, interacting, explaining, telling, showing, demonstrating, and establishing effective norms for discussion and communication. In these learning environments, teachers should also monitor the setting for doing mathematics in which the students are making sense of their experiences and growing understandings, they have autonomy with respect to the methods they use to solve the problems and they themselves decide whether an idea or solution is correct or reasonable, and the classroom culture exhibits an appreciation for mistakes as opportunities to learn (Hiebert, Carpenter, Fennema, et al., 1997). Furthermore, in effective mathematics classrooms that integrate the recommended processes and practices, students actively and fully participate in the carefully designed learning activities and continually reflect on their activity as well as other students' comments and ideas.

According to NCTM's problem solving standard, students should solve mathematical problems "for which the students have no prescribed or memorized rules or methods, nor is there a perception by students that there is a specific 'correct' solution method (Hiebert et al., 1997). Students should also discuss and explicate their reasoning while explaining to each other the steps of their solution strategies.

One of the most important studies that provide details into how mathematics is taught in the United States is the Third International Mathematics and Science (TIMMS) video study conducted in 1995. National samples of teaching were collected in three countries from 81 U.S., 100 German and 50 Japanese eight-grade mathematics classrooms. This video study was a small part of the larger TIMMS study with 41 countries and three different grade levels. With the goal of investigating how eight-grade mathematics was taught in the U.S. and in

Germany and Japan, the researchers videotaped one lesson in each classroom (Stigler & Hiebert, 1997). The following quote describes the nature of most common mathematics teaching practice observed:

The typical eight-grade mathematics lesson in the U.S. is organized around two phases: an acquisition phase and an application phase. In the acquisition phase, the teacher demonstrates or leads a discussion on how to solve a sample problem. The aim is to clarify the steps in the procedure so that students will be able to execute the same procedure on their own. In the application phase, students practice using the procedure by solving problems similar to the sample problem. (Stigler & Hiebert, 1997, p. 18)

Besides this common teaching practice in the U.S., there are two important findings of this study that provide significant insight into how mathematical rigor might look like in the classroom. First, mathematical concepts and procedures can be either simply stated or developed through examples, demonstrations and discussions. When a procedure is developed, students investigate why the procedure works and go beyond its accurate execution. While the average percentage of topics containing concepts that were developed was around 80 percent in both Germany and Japan, it was 20 percent in the U.S. Likewise, while the average percentage of topics containing concepts that were simply stated was around 20 percent in both Germany and Japan, it was 80 percent in the U.S. This finding gives us a good sense of what American students and teachers are not doing in the mathematics classroom.

Second, the nature of work students do in the mathematics classroom can be grouped into three categories: practicing routine procedures, applying concepts in new situations, and inventing new procedures. According to the TIMMS video study, average percentage of seatwork time spent in these three kinds of tasks in

Germany and the U.S. was very close, but, was significantly different in Japan. In both Germany and the U.S., between 90 and 95 percent of seatwork time was spent practicing procedures. Time spent applying concepts and inventing procedures were less than 5 percent each. Time spent in these two rigorous and conceptually demanding tasks were slightly less in the U.S. than in Germany. In contrast with Germany and the U.S., Japanese students' average percentage of seatwork time spent in these three kinds of tasks were: 40 percent practicing procedures, 40 percent applying concepts, and 20 percent inventing strategies.

Vis a vis these findings, Stigler and Hiebert (1997) write: "But to assume that Japanese teachers are less active or directive than German or U.S. teachers would be a mistake. Although it is true that Japanese teachers give students time to struggle with challenging problems, they often follow this up with direct explanations and summaries of what the students have learned. This is why Japanese teachers were coded as engaging in more direct lecturing than either German or U.S. teachers. Although the time devoted to lecturing was minimal in all three countries, 71 percent of Japanese lessons contained at least some lecturing, compared with only about 15 percent of German and U.S. lessons" (Stigler and Hiebert, 1997, p. 18). Thus, this study has significantly contributed to our understanding of the nature of mathematical problems and activities that American students engage in mathematics classrooms.

Rigor in history. This review is focused on the research tradition that emphasizes the importance of helping students to adapt more disciplinary modes of reasoning. Thus, a discussion of the teaching literature in history education must begin with a subject specific definition of rigor. This definition will enumerate the habits of mind that are valued in the history community. History and social studies are subjects that straddle both the

humanities and the social sciences. Historians offer theories or reasoned arguments about change and continuity over time, usually in the form of a narrative account of the past based on the careful consideration of available evidence (Seixas, 1996; Wineburg, 2001). Historical narratives are rarely, if ever, evident from piecing together the evidence, however. Historians must use a number of tools and theories to interrogate and interpret the evidence (Wineburg, 1991). Many of these tools, such as econometrics, anthropology, forensics, archaeology, statistics and social theories have emerged from the social and natural sciences, others, such as textual analysis emerge from the humanities.

Ideally, history/social studies teachers should provide experiences that strengthen their students' abilities to use factual knowledge, historical concepts, and interpretation techniques to make sense of the past. Teaching students to make sense of the past, however, is not the only goal of history/social studies teaching. The reason that the subject is included in the school curricula is to prepare the next generation for democratic citizenship (Hess, 2009; Reuben, 2005; Westheimer, 2004). This includes knowledge about government, as well as the origins and development of the United States and the rest of the world. It also includes a set of dispositions, such as considering evidence before making a decision, empathizing with people whose life circumstances are different than one's own, and playing an active, positive role in one's community. These dispositions, or habits of mind, are more difficult to measure using standard behavioral objectives and measurement techniques, such as multiple-choice tests (Reich, 2009). There is, nevertheless, a broad consensus that these civic purposes of history/social studies instruction are crucial aspects of democratic citizenship that schools should help foster (Barton & Levstik, 2004; Wineburg, 2001).

To provide a general overview of research on rigorous history teaching, it is useful to identify a

few key features of rigorous practice. What emerges from the literature is not so much a particular style of teaching (Barton & Levstik, 2004), for example student centered or teacher centered (Wilson and Wineburg, 1988; Grant, 2003), but rather ambitious goal setting based on the conceptual, knowledge and academic skill needs of students (Grant, 2003; Grant & Gradwell, 2010). It is difficult to narrow such broad ideas into a set of behavioral categories. Nevertheless, a few areas emerge as particularly important: conceptual focus, historical literacy (including writing), conceptual explanations, and classroom discussion.

Conceptual focus. Beginning in the late 1980s, a number of researchers responded to the call made by Shulman (1988) for in depth studies of teaching that focused on the *pedagogical content knowledge* of teachers. Researchers at this time made important findings in regards to the way in which conceptual focus supports rigorous pedagogical practice in history/social studies classes (Wilson, 2001). Onosko (1990; 1989) found that more successfully rigorous teachers were those who placed "thinking as the central focus with content understanding a valued outcome" (Onosko, 1989, p. 191). Like other scholars (e.g. Barton & Levstik, 2004; Grant, 2005; Wilson & Wineburg, 1988; Wineburg, 2001), Onosko (1990; 1989) found that rigorous teachers prized depth over breadth, and had more well-thought-out and elaborate definitions of thinking than less rigorous teachers did. Onosko also found that these teachers framed thinking as dispositions, or habits of mind, such as: skepticism of historical claims, looking for evidence to support arguments, suspending judgment before coming to a conclusion, willingness to entertain other perspectives (see also Barton & Levstik, 2004; Grant, 2003; Levesque, 2008; Wineburg, 2001). Similarly, when studying the extent to which teachers were effective at teaching their students to use higher-order-thinking, Onosko (1990) found that the more rigorous teachers' lessons were

more focused, coherent, included more opportunities for students to explain their answers, and to have their reasoning—rather than their answer—critiqued and challenged (see section on discussion below).

Many of the studies inspired by Shulman's (1988) call for research has been focused on teacher content knowledge and understanding (e.g. Wilson & Wineburg, 1989). In their review of research on history/social studies teaching, Barton and Levstik (2004) were critical of the narrow focus on teacher knowledge, citing studies that indicate that teacher instructional goals are a more salient factor in regards to actual pedagogical practice (e.g. Grant, 2003).

Scholars such as Au (2007), have raised the concern that the current focus on preparing students to perform well on high-stakes exams has altered the pedagogical focus of teachers away from disciplinary rigor. Recently, a group of scholars have attempted to study the extent to which teacher practice in 6 states, including Virginia, with high-stakes history exams are focused on student conceptual growth in history/social studies. Called the Social Science Inquiry Research Consortium (SSIRC), the group studied the relationship between classroom instruction and student achievement on standardized history/social studies tests (SSIRC, 2011). SSIRC researchers observed 52 teachers at 17 school sites in the six participating states. The researchers used a protocol developed by Newmann and associates (1996) for assessing the extent to which classroom teaching exhibits four key elements of rigor:

- ◆ Higher-order thinking
- ◆ Deep knowledge
- ◆ Substantive conversation
- ◆ Connection to the real world

Higher-order thinking was operationally defined as activities in which students are engaged in

problem solving and are expected to be producers of knowledge who manipulate facts and ideas in order to arrive at a conclusion through some form of synthesis, generalization, or explanation. *Deep knowledge* was operationalized as the organization of instruction around the central concepts of a discipline (see also Wiggins & McTighe, 2006). For history/social studies these include the idea that history is an attempt to explain change over time through a rigorous, but fallible, analysis of the evidence, and synthesis of that evidence into a plausible narrative (Lee, 2005; Levesque, 2008; Seixas, 1996; Wineburg, 2001). *Substantive conversation* was a measure of the extent to which there was sustained back and forth among teachers and students focused on the deep knowledge of the lesson that is not controlled entirely by the teacher. Finally, the researchers measured the level of *connectedness to the real world*, or the extent to which classroom learning is connected to the lives students lead outside of schools and to persistent public issues.

The first report from this study (SSIRC, 2011) found that 78.9% of the teacher participants were not teaching in a way that would be regarded as focused on student understanding of history/social studies concepts. This finding is consistent with research on history/social studies teaching conducted over the past 40 years (for reviews see Barton & Levstik, 2004; Seixas, 2001; Wilson, 2001). The researchers found some evidence that students whose teachers were more rigorous outperformed the students whose teachers were less rigorous on standardized tests, but the correlation between test scores and rigor were not statistically significant. This finding furthers the argument that the tests being used to measure achievement of history standards do not accurately measure student understanding of disciplinary concepts (see also Reich, 2009).

Historical literacy. The study of history pedagogy has benefitted over the past few decades from cognitive studies of reading and literacy. Researchers have taken studies of reading in

history (Beck, McKeown, & Gromoll, 1989) and coupled them with a deeper understanding of historical thinking (Wineburg, 2001), creating new frameworks for *historical literacy* (Wineburg 2009; Reisman, 2012; Monte-Sano, 2011). With historical literacy, scholars have been able to build on earlier studies of historical thinking (e.g. Seixas, 1993; Wineburg, 1991) and operationalized some specific skills and strategies that help students read and make sense of historical texts. This research has informed effective curricular reform efforts (see Reisman, 2012 below).

Kucan and Beck (2003) found that students understand texts, and remember more information from them, when they conduct a mental conversation with the author. Reading research has shown that this is what competent readers do with all kinds of texts that they read. Researchers in historical thinking, however, point out that reading is not a set of universal skills that transfer from one domain to another (Moje, 2008). Different genres require different conversations between reader and author. In history, the two major genres of writing include textbooks and historical documents. Textbooks, as Beck and McKeown (1988; Beck, McKeown & Gromoll, 1989) found, pose some serious hurdles for a struggling reader. Understanding them, even at the elementary level, requires more background knowledge than most children have (Beck & McKeown, 1988). In addition, the lack of a personal authorial voice in textbook writing (Paxton, 2002), a specialized academic vocabulary (Hinchman & Zalewski, 2001) and an omniscient voice that suggests that there are no controversies or unsolved mysteries in history (Paxton, 2002; Wineburg, 2001) all serve to make textbooks a hurdle, rather than an aid for many students. A number of studies have shown that when texts are written in more reader friendly ways, such as making fewer assumptions about background knowledge (Beck and McKeown, 1988), and writing in a personal rather than impersonal voice (Paxton, 2002), more students are more able to remember more information.

The other genre of history writing that has become more popular among classroom teachers are historical documents. The reading of such documents poses different problems than do textbooks. For example, Wineburg (1991) compared how Advanced Placement history students in an elite high school approached the reading of historical documents with the approach of a group of professional historians. He found that the high school students had learned to read for information, but not how to read historically. As a result, they were unable to draw a conclusion from the texts that they read, or to construct an accurate depiction of an event. Evidence has emerged in both the UK and in the US that approaching the difficulty of teaching and learning history by focusing on disciplinary literacy can be effective (Lee & Ashby, 2000; Reisman, 2012). Recently, the importance of student writing, particularly the opportunity to write multiple drafts, has come into focus as a major area in which rigorous history teachers can engender higher-order-thinking as well as higher order academic skills (Monte-Sano, 2011; 2008).

Reisman (2012) explored the results of a quasi-experimental treatment-intervention study in an urban California district. The study was designed to measure the extent to which a more rigorous approach to historical study would affect "(a) students' historical thinking; (b) their ability to transfer historical thinking strategies to contemporary issues; (c) their mastery of factual knowledge; and (d) their growth in general reading comprehension" (p. 86). Teachers who were in the treatment group received extensive professional development and fully developed unit and lesson plans that covered U.S. history from early European settlement to the Vietnam War. The PD and materials inverted the traditional approach to teaching history. Rather than being told a story and asked to memorize details of it for an exam, students were asked to read historical documents and to come to reasoned conclusions of their own. In these *document based lessons*

(Reisman, 2012), students were guided by their teacher through “four distinct lesson segments: (1) Background knowledge; (2) Central historical question; (3) Historical documents; and (4) Discussion” (p. 89).” The study found that students in the treatment group had statistically significant improved general reading skills, historical thinking skills, and factual recall (i.e. standardized test performance) compared to non-treatment students. The latter finding replicates that of Nokes, Dole and Hacker (2007) who also found that an approach to history that focuses on students’ ability to read, interpret and synthesize an historical argument from documents increases factual recall. Perhaps most significantly, the Reisman (2012) study found that treatment effects were more pronounced among the subgroup of struggling readers. In other words, struggling readers in the treatment group improved significantly more than their non-treatment counterparts on tests of historical thinking and factual knowledge.

Historical explanation. Effective history teachers are able to provide students with powerful explanations of historical events and phenomena (Leinhardt, 2001; Paxton & Wineburg, 2000). Leinhardt (2001) explains that in history, explanations are designed to help students understand historical events (e.g. the signing of the Emancipation Proclamation), structures (e.g. Lincoln’s Presidential power in 1863), and themes (e.g. freedom, White nationalism). Pedagogically powerful explanations are achieved through asking good inquiry questions, such as those that connect to students prior knowledge and (mis) understandings, are compelling, and are designed to help students deepen their understanding (Wiggins & McTighe, 2006). To do so, teachers need to know what is important in the subject, what is problematic for students to learn, and how students will consider the problem initially (Leinhardt, 2001; 1993). As such, these explanations may occur at discrete moments in a lesson to explain a single event, or be woven into

the work that students do over the course of a year (Leinhardt, 1993). It has been suggested that teachers who are effective at raising standardized test scores while not compromising the quality of instruction are able to develop inquiry questions that get at the heart of the underlying historical theories that underlie the construction of test questions (Reich & Bally, 2010; cf. Wiggins & McTighe, 2006).

Good explanations begin with good questions. Leinhardt (2001) also identified two other crucial aspects of explanation: examples and representation. A common structure for historical explanation is to start with a definition, list examples, use representations such as graphs, charts, maps and allegories, and to include a poignant story that hooks student interest emotionally. Examples are used to connect prior knowledge to new information, to prompt and resolve errors, to demonstrate a when a principle applies, and when a principle does not apply, as well as to help students understand the inquiry question. Another powerful use of explanation is to compare two historical events, unpacking elements of each that are similar or different. This sort of comparison, when done in a classroom dialogue, helps to model an important form of historical reasoning for students, and helps them see the importance of using content knowledge to contextualize an historical event or idea. Examples are effective teaching tools when the teacher is clear about what idea, structure or theme they are trying to exemplify. Leinhardt (2001) cites research that shows that it is usually a good idea to use multiple examples in an explanation. To be useful, representations should “connect in relevant and explicit ways to the explanation being developed” (Leinhardt, 2001, p. 348). That said, the danger of using representations in an explanations is that they can confuse students as well oversimplify and otherwise distort the explanation of an idea, event or theme.

Classroom discussion. In history/social studies instruction, discussion is highly valued, but rarely attempted and often poorly executed (Hess, 2004). Hess (2004) defines discussion in the following way:

First, discussion is dialogue between or among people. It involves, at a mini-mum, the exchange of information about a topic (a controversy, a problem, an event, a person, etc.). Second, it is a particular approach to constructing knowledge. The approach is based most fundamentally on the idea that something positive can occur when people are expressing their ideas on a topic and listening to others express theirs. ... it takes many forms and is used for many purposes. (p. 152)

When orchestrated well by a teacher, discussion can be a key tool for raising academic rigor in the classroom (Hess, 2009; Kucan & Beck, 2003; Onosko, 1990; Rossi, 1995). As Hess (2004) points out, the interplay of diverse ideas and information in good discussions provides a crucial opportunity for students to practice the skills of critical thinking, including the complex forms of historical thinking mentioned above. Perhaps more importantly, it is through deliberative discussion that young people learn the skills of democratic citizenship (Hess, 2009; 2004; Westheimer, 2004; Westheimer & Kahne, 2004).

Unfortunately, discussions such as those outlined above appear to be rare events (Nystrand, Gamoran, Carbonary, 1998; SSIRC, 2010). One study (Nystrand, et al., 1998) found that 90 percent of social studies instruction in 106 middle and high schools contained no discussion at all. What discussion did exist consisted of exchanges lasting less than one minute. Wilen (2004) calls these short interchanges "a quasi-discussion form called recitation" (p. 33) that is primarily aimed at assessing student attention to teacher talk.

In a study of 58 teachers in 8 states, the SSIRC (2010) found that authentic pedagogy, including discussion, was more likely to occur in classrooms

that were predominantly white and female, and less likely to occur in classrooms that were predominantly made up of students of color. Overall, this study (SSIRC, 2010) found that 42 of the 58 teachers observed exhibited *minimal or limited* authenticity, a judgment that includes an assessment of the level of classroom discussion. Teachers exhibiting minimal authenticity primarily lectured with power point and recitation rather than discussion. Even when they engaged students in project based work, there was little opportunity for students to discuss their work with their peers.

Good discussions begin with questions for which there is no one obvious correct answer (Bain, 2006; Hess, 2004; 2009; Newmann, 1996; Wiggins & McTighe, 2006). In her review of the relevant literature on discussion in social studies classes, Hess (2004) concludes that

virtually all of the case studies of high-quality discussions in the literature share as their central feature a problem, text, topic, question, or issue that provokes multiple interpretations. (p. 154).

Good discussions are more likely to be the result of careful teacher planning and orchestration (Hess, 2009), from the pre-planned questions to the attention given to preparing students with the information and preparation needed to make meaningful contributions. Another crucial factor in the existence of good discussion is the classroom culture that the teacher co-creates with his or her students (e.g. Bain, 2006). Classrooms that value habits of mind such as listening, respect for differing opinions, the use of evidence to support claims and a cooperative rather than competitive ethos help students feel comfortable sharing their views and taking risks (Hess & Poselt, 2002).

Conclusion

Policy makers and members of the general public have been anxious about the state of education

in this country since the early 1980s. Chief among these concerns has been the fear that high school graduates will not have the academic skills and knowledge needed to be successful in post-secondary educational institutions and to compete in the global economy. Policy makers have chosen to address this situation with a system of accountability that relies heavily on standardized tests. Critics of these policies have pointed out that these tests measure the attainment of only a fraction of the academic skills and conceptual knowledge that students need to be successful.

Scholars who study academic rigor have found that it is more likely to exist in schools with cultures that foster high expectations of all students and that have an overall focus on providing students with educational experiences that challenge them. Education scholars who focus on particular disciplines have added much to these findings. These scholars have enumerated specific academic and pedagogical skills that are crucial to rigorous instruction in a particular discipline. This literature is particularly useful for helping stakeholders to make sense of what rigorous instruction looks like in a math, history, or science class. We suggest that the scholarship on disciplinary learning contains key insights into how more rigorous pedagogical approaches might be developed.

The Study: Methods and Case Study Findings

Methods

This is a qualitative case-study of the daily classroom teaching practices of three "rigorous" math and social studies teachers. Two social studies teachers, teaching six and eight grades, and one mathematics teacher, teaching ninth grade geometry class, were each observed for four to six times for a total of approximately five hours. Teachers were asked to select what they believed were their most rigorous lessons. For two of the teachers, these were a number of visits to observe individual lessons that were spread across the school year. For other, the visits concentrated on a particular unit. All the classes observed were medium or low tracked and included learning disabled students. Following the work of Newmann (Newmann, 1996), a unique research protocol and data collection instrument on rigorous instruction was used during the observations. After each observation, the teachers were also interviewed for thirty minutes. The field notes, interview transcripts, classroom artifacts: handouts, lesson plans, and student work form the basis of rich case descriptions of rigorous classroom practice. The data from the research protocols provide information about

particular aspects of the teachers' practice, including higher-order thinking, connections to the world outside of school, deep disciplinary knowledge, and substantive discussion.

Case Study Findings

Case Study 1

Mrs. Zweibel, 8th Grade Economics

On an overcast morning in early October, we arrive at Stapleton (pseudonym) Middle School. The school is situated on a busy road in an upper-middle class suburban area. The 2014 8th grade civics and economics cohort performed well on their end-of-course SOL exam (see Table 1, below). 94% of students passed this exam, 43% passed it with an "advanced proficiency" score, compared to a pass rate of 85% for the division, and 83% for the entire Commonwealth. The school is well lit, and clean. Hallways between classes are loud and rambunctious but fairly quiet during class. There are, however, hall wanderers at all times.

Ms. Zweibel (pseudonym) teaches several sections of 8th grade civics and economics. She teaches

Table 1

2014 Pass Rates on the 8th-Grade Civics and Economics SOL Exam.¹

Area	All Students	Female	Male	Black	Hispanic	White	Two or more races	Disabled	Economic Disadvantage
School	94	95	94	81	91	96	82	79	68
Division	85	86	85	75	75	92	88	56	72
State	83	84	83	71	75	89	86	50	71

¹Note that the demographic information for these sub-populations is not included in the school report card. Therefore, pass rates for smaller sub-groups (Black, Hispanic, Two or more races, and possibly Economically Disadvantaged) should be read with the understanding that the smaller the population, the less reliable and meaningful average pass-rates are.

both high- and low-tracked cohorts. All of our observations were of the low-tracked classes; and these classes included students with disabilities and tended to be more ethnically diverse than the high-tracked classes. The first base-line observation occurred in the Fall, and subsequent observations were performed in the Spring while a problem-based learning (PBL) unit on economics was being taught and learned. Several issues stand out in these observations. The first is the difference in the apparent intrinsic motivation and effort on the part of the students early and later in the year. In October, students appeared unmotivated, answering questions minimally, if at all. This was despite the efforts of Ms. Zweibel to create student-centered lessons that connect to the world outside of school. In April, however, these same students approached their work very differently. Where apathy once reigned, students appeared to be working very diligently. In this case study we compare a Fall lesson with class sessions in the Spring in which students were involved in a project-based unit on economics. Special attention is paid to accountability structures across these units, and especially to the design and execution of economics unit.

The first observation we made was in the Fall, the semester that the course focuses on civics. During that class period, students were working on a worksheet about local and state elections that were coming up in November. The worksheet asked students to make sense of county-wide elections and a referendum. Ms. Zweibel was careful to connect academic learning from the SOLs to the world outside of school, and in this case, to local elections and a proposed referendum to impose a meal's tax in the county to help pay for capital improvements to schools.

Overall, the students were less than enthusiastic about this task. Some worked diligently with their groups, others were easily distracted. Ms. Zweibel was not particularly vigorous in applying academic

press. There were a couple of pedagogical moves that stood out as features of her teaching; and these were also observed throughout the year. The first of the moves was that Ms. Zweibel's students learn to take personal responsibility for completing assignments. Student responsibility came about in diverse contexts within this lesson. Early in the lesson, students were working on developing their own academic goals based on weaknesses that were identified over the first 9 weeks. The students were asked to explain why they think they struggle in particular areas and set goals for improvement. Throughout this activity, Ms. Zweibel gave suggestions for possible actions students might take. She ended it by reminding students of a trip they had taken the previous week to a local college. In a discussion about the trip, she asked the class "what was your sense of the college trip?" One student responded that college students "don't get a lot of free time" because a college student that talked to the group said that he "studied a lot." Ms. Zweibel used this example to highlight the importance of student responsibility, saying "I never knew [college] wasn't like middle school, high school, with scheduled classes. You have to decide how to use your time." She explained further that "you have so much more responsibility in college. You have to get [to class] on time. There aren't any bells."

During the class period, most of the work focused on a law that was going to be offered as a referendum in the upcoming election. Students were working together on a worksheet that had asked them to figure out what different political party and interest group positions would be on this plebiscite. The students struggled with the task. Some of the vocabulary, although already taught, was not remembered when students saw it in the work. The teacher did use academic press exhorting the class to complete the assignment, but actual completion was left up to them; one exception was vocabulary. When vocabulary issues surfaced, she would stop the class to help

them remember the definition of words, such as “represent,” “representative democracy,” “referendum,” and delineating concepts such as local, regional and state-wide in regards to the positions sought by candidates and the jurisdictions of the proposed laws. The attention paid to details and to specific meanings of words, rather than letting words go undefined, was the strongest aspect of the discussion that occurred. Students were asked to create *hashtags* for tweets to express and categorize their opinions of the proposed referendum. At one point a student was called on to read the proposed referendum.

Ms. Zweibel: “What does that mean?”

Student A: “I don’t know.”

Ms. Zweibel: “Increase?”

Student A: “Increase education in schools.”

Ms. Zweibel: “Increase what specifically?”

Student B: “Improvement? Um...”

Ms. Zweibel: “How about someone else.”

Student C: “Raise debt to improve schools.”

Ms. Zweibel: “Do I agree that the county should go into debt, 3-4 million dollars, to build schools? Hash tag?”

Student D: “#we’re gonna be in debt.”

Ms. Zweibel: “Is that what it’s about?”

Student B: “Schools improvement.”

Ms. Zweibel: “Okay so, #indebtforschoolimprovement or #loansforschoolconstruction. Those were models. Now you come up with your own.”

Despite this detailed exchange, however, students working together in groups had low motivation to complete the task carefully, and therefore they quickly lost focus on it. Later in the period, perhaps in frustration, Ms. Zweibel tried to refocus the class but answered some of her own

questions, and students seemed to struggle with the idea that people’s personal situations can affect how they perceive the public good when voting.

There were also a number of moves in this lesson that supported the approaches outlined in the review of literature on rigorous teaching. Although these moves do not appear to have an immediate effect, they are still very important. Ms. Zweibel designed an inquiry lesson that identified an important big idea: how people perceive what is in their interest when deliberating on the public good. The content was connected to students’ lives and the activity required students to activate civics content, including vocabulary and facts about local government and elections. Ms. Zweibel asked follow-up questions that focused students on their reasoning as much as on whether they had given the right answer. Although the class never gets out of control, the assigned work was not completed by many in the class. Evidence from discussion between the teacher and the students did not indicate that they understood the larger ideas at stake.

We returned to observe Ms. Zweibel’s class in late April, visiting four times between April 30th and May 12th. Students were working on their final project before the SOL exam in 8th grade civics and economics. Rather than using this time for extended review, Ms. Zweibel spent it on an extensive economics project in which students design a product, conduct market research, create a business plan, and produce and sell the products at a trade show. In an interview, Ms. Zweibel explained that the project was designed in such a way that issues such as vocabulary, content knowledge, collaborative skills, problem solving and assessment are all seamlessly interlinked and mutually supporting because “making them all intertwined together [helps students] see all the connections.” Ms. Zweibel approaches project design as a process that is always evolving. She explained that at one time

she gave a vocabulary unit to students, thinking they'd need the vocabulary to complete the project. She then abandoned this approach for one in which vocabulary is taught as it arises as a useful tool to help students complete a particular task. In addition, skills such as reading, making inferences, supporting arguments with evidence and cooperating are taught throughout the year so that students have the interpersonal and academic skills to complete this project.

The project was segmented into bite size chunks with manageable amounts of work due each day. Students who were not keeping up with early deadlines were assigned an alternative project. They would use the same packet that the rest of the class used, but rather than design their own product, they had to read a novel about a kid their age starting his own business. All students received a set of handouts that included a business plan, an application to for a business license, a market survey, marketing planner and a business owner journal. The logic behind the order in which these tasks and others are approached is based on the process of starting a business: designing a product, assessing its cost, conducting market research on the demand for it, marketing the product, bringing it to market and finally assessing profits and losses. Economics concepts and vocabulary are parsed out in such a way that they are taught when students need them. For example, when students are ready to assign a price to their product, Ms. Zweibel will spend time teaching it, assigning practice exercises and then allowing students to figure out what they will charge for their own product.

A poignant example of teaching economics is the work Ms. Zweibel did with her class on the concept of equilibrium price. Equilibrium price, the price at which supply equals demand, is difficult to understand because it involves some counter-intuitive ideas. Ms. Zweibel explained to us that evidence from earlier class discussions indicated that students lacked a disciplined approach to pricing. Students tended to think

that products should be sold for a lot of money or as little as possible. Ms. Zweibel began by showing the class a graph that had price as the X axis and demand as the Y axis. The discussion of equilibrium price began with a real-world example: pricing at "dollar" stores. Interspersed in this conversation were a number of vocabulary words (in italics) that students had the definitions to already.

Ms. Zweibel: "Do dollar stores ever sell everything?"

Student A: "If they do, they restock [the store]."

Ms. Zweibel: "What about after a holiday? What happens if they sell-out quick?"

Student A: "Then the price was too low."

Ms. Zweibel: "That's a *shortage*! There was not enough *product*, and *demand* was greater than *supply*. Any times that's happened?"

Student A: "iPads when they first came out."

The dialogue continued with more real-world examples of attempts to find the equilibrium price, which Ms. Zweibel re-defined as the price where "two competing people find a secret spot where both are happy." Next, students had to make use of data that was collected in a market survey of students in their school. The data consisted of indicators of the demand for the different products that students have designed, and the prices that potential customers feel comfortable paying for these products. The students, in teams and alone, in the case of sole proprietors, used a worksheet to graph the supply and demand for their products in order to find the equilibrium price. While they were doing this, there was a graph projected on the board, that indicated the amount that surveyed students said they'd be willing to spend on a single product. She also explained that in the research, most students said that they would bring \$10 to the trade fair, explaining further that this means students can buy a couple of things or spend all their money on one product.

While students were working, Ms. Zweibel circulated around the room, stopping to discuss prices with different groups. The following is a transcript of one of those conversations:

Ms. Zweibel: "What are we doing here?"

Student: "We gotta make 20 of these [duct-tape butterfly hair pins]."

Ms. Zweibel: "Discuss the price cost, and include tax. Why do you say that duct-tape is \$1 plus tax?"

Ms. Zweibel walks away and the students continue to discuss the materials they will have to buy to produce the product. They use their smart phones to look up different prices for materials, the production process, and how much they should charge for the items.

Student A: "I think we should make them [products] \$1.50-\$2."

Student B: "Really?"

Student A: "Thinking how much it would cost [to produce]."

Student B: "That's the maximum, \$1-\$2."

Student A: "That's the maximum? The highest? But most are willing to pay \$5."

Student B: "I say a dollar."

Student A: "Okay fine, I'm always wrong."

The discussion about pricing continued, and some vocabulary words were used. Students then finished working on their graphs and made a decision about what they thought would be the ideal price for their product. They placed a sticky note next to their prototype with the price they were planning on charging. Students from this section and another section of this course taught by a different teacher switched classrooms. Students in the two classes circulated around the room and wrote comments on the sticky notes that contained the potential price of the product. The students returned to their classroom and reflected on the feedback from other students.

The project-based learning experience designed by Ms. Zweibel had several components that led to its overall success. First, Ms. Zweibel had stressed student accountability throughout all of the observed lessons. Projects and activities were broken into more manageable chunks; and accountability and academic press, to complete the assignments well, were recurring themes. Ms. Zweibel designed activities around reinforcing content knowledge by having students use that knowledge to practical ends. The first observation included a well-designed activity, but student motivation and attention was low. In the Spring observations, students were more motivated and attentive. They had spent months getting used to Ms. Zweibel's procedures, academic skills, such as making inferences and supporting arguments with evidence, as well as the interpersonal skills that this project requires. In addition, accountability for performance on the final project was distributed from Ms. Zweibel to the students themselves. Students knew that they would be involved in a public demonstration of what they had learned at the trade fair. Those students that chose to work in groups had learned about their classmates' reliability in regards to getting work done and meeting deadlines. Ms. Zweibel explained in our interview that this experience prepared the students to make sound judgments about whom to collaborate with, or whether they preferred to work alone. Group members were accountable to each other as much as to Ms. Zweibel, which removed some of the pressure and resistance that normally occurs in more teacher-centered pedagogy.

A second issue that was instrumental to the project's success was the engagement of Ms. Zweibel herself to the design process in regards to this project. In an interview, she explained that she has changed the project significantly from year to year. Changes were made as she learned more about what her students learn, and tried out different configurations to see if they enhance learning further. The "data" used to inform these

decisions comes from the richness of the project itself, as well as the opportunities that it affords her to learn about student reasoning. First, there is extensive work that the students do in relation to this project. Because the work is parsed out throughout the duration of the project, she has many opportunities to check for understanding in written work. While students are working on their own, she moves around the room engaging them in conversations about their work. These formal and informal checks for understanding have led to changes in the project. She explained that:

Ms. Zweibel: "I used to start off with basic economics vocabulary alone and that wasn't nearly as successful as ... [looking at] what kinds of business there are and going from that perspective first. Then we bring in the vocabulary when they start making choices about their business. The [vocabulary] words are going to be throughout the whole thing. Unit 1 used to be econ vocabulary, unit 2 businesses and the economy, unit 3 the US economy. But now I'm making them all intertwined together makes them see all the connections. Opportunity cost sounds like such an easy concept to an adult, but kids don't get it. They don't get that it is the opportunity you give up. They just think 'I have all these opportunities! I should get to pick 1.' But after we do all this, they get it, they understand that you have to make choices and that you give something up when you do. Because we've broken it down but we are using these ideas throughout the whole process."

Clearly, the design process is an ongoing one; it is fair to say that the project that she has designed is never complete or perfect. It is an instrument through which students learn, and through which Ms. Zweibel learns about students. The learning goals, from the cognitive ones to the inter- and intra-personal ones may evolve as well, although they appear to do so more slowly. Ms. Zweibel is more focused on the mechanics of the project and how those mechanics help enhance the achievement of these goals.

Case Study 2

Mr. Smythe – 6th Grade U.S. History

Mr. Smythe (pseudonym) teaches in Bethune Middle School (pseudonym), a title 1 school that is not accredited by the Commonwealth of Virginia. Pass rates on the 6th grade ELA SOL are 39%, and 45 % for the 6th grade math SOL. At Bethune, the one test whose pass rate has been an anomaly for the past 3 years is the Virginia and U.S. History to 1865 SOL exam, a curriculum that Mr. Smythe teaches exclusively, although not alone. The overall pass rate for this exam is 75% (see Table 2). Mr. Smythe reported that in the year he was observed, his students passed the SOL exam at a rate of 83%. Mr. Smythe's class was observed on three separate occasions, once in October and twice in April. Consistent with the criteria for inclusion in this study, Mr. Smythe teaches regular track classes that include learning disabled students. Our visits to other social studies classrooms in the district, which are also not "honors," have tended to confront the challenges of test-preparation in ways that we felt were counter-productive. The pattern of instruction in most appeared to be:

1. Present students with the facts through power-point presentations and close notes.
2. Limit the amount of reading that students are asked to do.
3. Assess students with SOL-like multiple-choice tests only.

However, the interview and observations of Mr. Smythe's class indicated that he was working with a different theory of teaching. This theory can be characterized by 7 ideas:

1. Analyze the SOLs and SOL exams for big ideas that connect the content in meaningful ways.
2. Analyze these documents to understand the skills students need to be successful on the final exam and in grade-level academic tasks.

Table 2

Bethune M.S. Pass Rates on Various Humanities SOL Exams.¹

Area	All Students	Female	Male	Black	Hispanic	White	Two or more races	Disabled	Low SES
Pass Rates for the U.S. History to 1865 SOL Exam									
School	75	68	85	74	NA	75	NA	58	75
Division	58	56	60	54		81		39	54
State	81	79	82	66		87		50	68
Pass Rates on the 6 th Grade ELA SOL Exam									
School	39	46	25	36	NA	40	NA	17	41
Division	40	45	39	36		59		16	36
State	73	77	69	65		81		38	51

¹ Note that the demographic information for these sub-populations is not included in the school report card. Therefore, pass rates for smaller sub-groups (Black, Hispanic, Two or more races, and possibly Economically Disadvantaged) should be read with the understanding that the smaller the population, the less reliable and meaningful average pass-rates are. In addition, Mr. Smythe is not the only 6th-grade teacher at Bethune M.S. His self-reported pass rate on the 6th grade exam was over 90%.

3. Design lessons so that students have active experiences in which they uncover big ideas themselves, and do this repeatedly over time.
4. Design student experiences so that they practice academic skills repeatedly over time.
5. When designing curriculum, think in terms of building student skills (academic and social) and understandings over the course of the academic year.
6. Assess students using classroom activities and multiple-choice tests with the goal of figuring out where they struggle, and adjust future activities in order to support student learning.
7. Use affective academic press.

Mr. Smythe was able to articulate most of these factors in our interview, which took place after the first observation. The first lesson we observed was an introduction to the Native American tribes of Virginia and to the discipline of archaeology. The main idea that Mr. Smythe wanted students to understand in this lesson was that archaeologists dig up artifacts and make inferences about the

cultures based on those artifacts. At the beginning of the lesson, Mr. Smythe told this to the class, and followed this explanation up with an activity. The activity consisted of passing out plastic boxes filled with sand and artifacts buried in that sand. Students had special tools to dig through a box and find artifacts, such as a bone fish hook, a seashell, or an arrow head. When they found an object, they would first describe it, and then make inferences about the culture of the group that would create such an artifact and the local natural resources. The activity was followed with a class discussion in which photos of artifacts were projected on the screen and the students built a story about a group of Native Americans based on the inferences they made about the objects. When asked about the design of this lesson, Mr. Smythe explained:

Mr. Smythe: "We were learning archaeology, so I thought there's no better way to know what an archaeologist does than to have them dig. And that's where the whole description and sketch [of the found objects] come in. I wanted them to wrap their heads around the idea that archaeologists don't just dig and say 'look I

found a rock' because they may not know what it is, so they need to describe it. So I just wanted to get them thinking. But the most important part to me was the last part where they had to draw a conclusion. That's taking it to higher level thinking. There not just thinking I've got a seashell, they are thinking outside the box. I was trying to take them through the process until they are at the higher level. And then after that, we were just trying to tie it into the natural resources. I figured it all just tied together, it flowed that way."

Consistent with his focus on student learning and the particular struggles that his students experience, Mr. Smythe explained that he organized student learning around a big idea:

Mr. Smythe: "The unit is basically the Native Americans. So the archaeology is the smallest part of it. What we'll move into now is the tribes, the Lakota, Iroquois, all the tribes. And it is paramount that they know the resources, because the main thing we focus on is how the natural resources affected how the tribe lived. So they've got to have a very sturdy understanding of the natural resources or else they can't succeed in the Indians. And actually the resources, we use those terms throughout the rest of the year, so they have to know them."

Rather than focus his planning solely on the district pacing guide, he focuses on a big idea, that natural resources and geography affect how pre-industrial people lived. He justifies the time spent learning this by explaining that this idea, and the vocabulary used to articulate it, recurs throughout the year." Mr. Smythe named several such ideas when he was interviewed in October, such as cause and effect, sequencing, map analysis, and analysis of primary sources for themes that recur throughout the year, such as the themes of freedom and equality that appear in the *Declaration of Independence* and Lincoln's *Emancipation Proclamation*.

Let's take one such idea: cause and effect. The first period of observation, in October, Mr. Smythe

had a warm-up exercise for his students that focused on cause and effect. When we returned in April to observe again, the warm up consisted of three questions:

- 1) Explain Clara Barton's role in the Civil War;
- 2) Sequence the following events in order: Fort Sumter, Battle of Vicksburg, Lincoln Elected, Appomattox Court House; and
- 3) Cause – Union takes Mississippi river → Effect?

After going over students' answers to questions 2 and 3, Mr. Smythe helped the class connect them to the language of the SOL. First he projected a blank map of the United States on the board. He had students draw the Mississippi river, show where Vicksburg is, and how the South was split in half after this victory, effectively ending trade along the river for the Confederates.

Mr. Smythe: "Where is Gettysburg?" [A female student raises her hand. A boy sitting next to her calls out that she is looking in her notes to see where Gettysburg is.]

Mr. Smythe: "You know what, I'm okay if she looked in her notes. That's why you take notes. How is Gettysburg different?"

Girl A: "North."

Mr. Smythe: "It is the only battle in the North, so it has to be the invasion of the North. We talk a lot about SOL key words. These are the words you should look for if you see a question about these events. What is the key word you should see if there is a question on Vicksburg?"

Boy A: "Mississippi!"

Girl B: "Splits!"

Mr. Smythe: "What is the key word you should look for if you see Gettysburg?"

Girl C: "Invasion of the North!"

Mr. Smythe: "Good! Also it is a *turning point* of the war."

Another big idea was sequencing. Sequencing was a big idea that they had spent time on throughout the year. In an observation in April, Mr. Smythe told the class “we need to work on sequencing. We need to work on putting things in order. Put these in order for me: abolitionist increase, slavery abolished, Louisiana purchase, increase in slaves, cotton gin.” While students worked, he circulated around the room, giving encouragement and engaging students in discussion when there was a misunderstanding or reluctance to commit to a particular answer.

Mr. Smythe: “Which of these events came first?”

Student A: “Louisiana Purchase.”

Mr. Smythe: “Why?”

Student A: “Because we talked about it [in class] first.”

Mr. Smythe: “Okay, that’s one reason to put it. Why else is this first?”

Student B: “Because we had to get that land to have more slaves.”

Mr. Smythe: “What did you say happened second?”

Student C: “Cotton gin.”

Mr. Smythe: “Why? How can we justify it?”

Student C: “It increases slaves.”

Mr. Smythe: “What did the cotton gin do to slaves?”

Student D: “increased them.”

Mr. Smythe: “What is next?”

Student E: “Abolitionist increase.”

Mr. Smythe: “Why?”

Student E: “They was mad about more slaves.”

Mr. Smythe: “Right, they were mad about slavery increasing in the West. And then the last one is slavery ended.”

In this way, Mr. Smythe helped students construct a logical narrative of events by sequencing them chronologically. This approach combines both a narrative logic and content knowledge. Students who are good at the first part can make logical connections between events even when they are not in chronological order. Without knowledge of content, logic alone seems to not work.

If this seems like “teaching to the test,” it is. The difference between Mr. Smythe’s approach, and the approach of many other teachers, however, is that he has built an idea of why his students do not do well on such tests. He focuses on connecting vocabulary and ideas from more student-centered interactive experiences to the problems they are likely to face on the exam. This work is congruent with research on how students answer history multiple-choice questions (Reich, 2009) and how teachers can best prepare students from marginalized communities for success (Reich & Bally, 2010). This is not to say that everything Mr. Smythe or any other teacher did in this study is perfect. Both social studies teachers tend to accept one word answers from their students, even when asking follow-up questions. In addition, Mr. Smythe had a habit of restating and elaborating student answers for the rest of the class: a practice that can encourage students to ignore each other and pay attention only to the teacher.

During the final observation, during a side conversation with the researcher, Mr. Smythe mentioned that he had noticed that students were not able to answer SOL exam questions that touch on the experiences of soldiers during the Civil War. He had all members of the class read three excerpted letters from soldiers written during the Civil War. He asked students to underline any words that describe “a sense” of the letters. When he asked the class about what they had underlined, they told him “horses running around,” “hearing gun shots,” “pieces of bodies.” Mr. Smythe would restate and elaborate upon what he heard, animatedly saying things like “see!

Arms, heads, legs are lying on the ground! Can you imagine 1000s of people dying every day?" Mr. Smythe handed out a sheet of paper that had the outline of a Civil War soldier on it. Under the outline the five senses were listed. Students were asked to describe what a Civil War soldier heard, smelled, tasted, saw and felt based on the historical documents that they had read. When they had completed this, Mr. Smythe asked the students to discuss what they had written with students sitting next to them. Three boys working together discussed what they had written, saying:

Boy A: "What you put?"

Boy B: "I put disease, sick."

Boy C: "We just gave some good ideas! Broken bones!"

Boy B: "What did they smell?"

Boy A: "Smoke in the air."

Next, Mr. Smythe asked the students to draw the five senses, showing a couple of examples from previous students. He told the class: "I don't want you coloring. What matters is you understanding what soldiers went through. What colors should their uniforms be?" Students responded "blue and gray." As they were working, Mr. Smythe circulated around the room. He asked one girl "let's look at the picture."

Girl: "I can't draw."

Mr. Smythe: "me neither! What do they smell?"

Girl: "Smoke!"

Mr. Smythe: "They smell smoke, how could you draw that?"

During this exercise, Mr. Smythe gave positive reinforcement to students, or what we are calling affective press. He would exclaim to the class "Ooh, I like what is doing. Next to each picture, she wrote a sense." He reminded the class that they would explain their drawings to the rest of the students and that "there is no way I

can explain a battle to you because I've never been in one. We just have to read the letters of soldiers and try to imagine what it was like." Mr. Smythe's students were often afraid of taking chances in class, and he worked hard to support their efforts with affective press. He focused on the strategies students employed and their effort, rather than whether they got the "right" answer. He was always in motion, especially when students were working at their desks, saying things like "focus," "that's what I like to see," and "you've got to write something." At the beginning of a lesson he told the class: "We have 1 month from Friday to Spring Break. When we come back we prep for the SOL. You guys are focused, grades are going up, attitudes are getting better. Every week I call five parents. I am going to have some positive calls to make."

Case Study 3

Mr. R.'s 9th Grade Geometry Class

Mr. R (pseudonym) teaches regular geometry classes at a suburban high school, Hoover High (pseudonym). He uses many computer activities that are designed to teach the big ideas of geometry. The computer activities in Mr. R's classes put students in experiential situations where students own their problems, engage in meaningful goal-directed activity and re-present it in their minds. Therefore, each day Mr. R's students get a better chance of facing occasions in which they notice conceptual discrepancies in their mental representations (Glaserfeld 1995). Furthermore, the computer activities allow Mr. R's students to self-generate questions and hypotheses that emerge in meaningful problem solving, which help them to place the activity in a broader perspective and thus expand its scope. Because all students are actively involved and own the activities in their own ways, this expansion of scope further helps them engage in unexpected generalizing activity that is rooted in their own personal goals and purposes. Mr. R

seems to accomplish this by allowing and encouraging his students to pursue their own solution strategies while guiding them by requesting explanations and asking critical questions.

For example, on April 23, during his sixth period regular geometry class, Mr. R let his students explore the results of rotating and reflecting an "L" shaped image on their computers. All students had a laptop computer and they all knew how to use the necessary tools of the software Geometer's SketchPad such as the point tool, arrow tool, circle tool, and etc. While the students were dragging the given shape to different parts of the screen to try and test if the resulting shape is a reflection of the original shape about a given line of symmetry, Mr. R was circulating around the room and encouraging them to first make sense of their individual solutions without worrying about the correct answer. He was not correcting them or giving them any rigid directions as to how to carry out the activity. Furthermore, he was telling them that "the mathematical perfection will come later." These two practices of encouraging different solution strategies and not focusing on correct answers during the initial phases of making sense of one's own activity are well documented in the literature as best practices in teaching mathematics (Stigler & Hiebert, 2004; Van de Walle et al., 2013).

Another effective teaching strategy observed in Mr. R's classes was the building of the new knowledge on students' prior knowledge and relating mathematical knowledge to students' real-life experiences. For example, on April 21, during his sixth period regular geometry class, Mr. R introduced "the last topic before the SOL," geometric transformations, with the question: "Is my face symmetric?" After tapping into students' prior knowledge about symmetry, during which students uttered mixed answers, "yes, no, yes, no," he displayed an image of his face on the smartboard. He then displayed an image of a butterfly and rotated it on the board using his

pen. He continued with a question "Have you seen the movie Angels and Demons?" and described a detailed story about geometric transformations found in the movie.

Mr. R also gave his students freedom to choose their own tools and encouraged them to evaluate their own thoughts. For example, on April 21, during his fifth period regular geometry inclusion class, Mr. R's students were engaged in cutting letters A through Z from a sheet that posed the question: "How many lines of symmetry?" The sheet included large images of all the letters from A through Z.

Mr. R: "How many degrees you rotate to obtain the same? Which letters have line of Symmetry? How many lines of symmetry does it have? Cutting is optional, you can write on the paper, you can draw lines on it."

While students were engaged in the activity of finding the number of lines of symmetry each letter has, Mr. R walked around the classroom and interacted with some pairs.

Mr. R: "Are you convinced in what she said?"

Mr. R: "I am not going to tell you. You decide. If you think it is, then it's good."

To further understand why Mr. R seemed to continually encourage his students to evaluate their own thoughts, we looked at his learning goals for his lessons. It seems that for Mr. R, computation is not the overarching mathematical process in doing mathematics; therefore, he does not seem to consider students obtaining right answers to the computational procedures as the manifestation of their mastery of the lesson objectives. His classroom activities require his students to explain and justify their reasoning, which prevent the creation of a classroom culture where right answers represent understanding. Obtaining right answers in mathematics is indeed important and necessary; however, designing mathematics lessons that primarily focus on the correct execution of computational procedures and algorithms does not allow students to make

connections and thus develop robust conceptual understandings. Mr. R discussed this in one of the interviews we conducted. Referring to his class on April 24, he said: "During fifth block I was not letting students have a rule. I didn't deny but I didn't legitimize their thought, 'you are correct with this rule.' I let them to check and hypothesize themselves."

Thus, Mr. R.'s lessons seemed to primarily focus on figuring out problems and making sense of the mathematics concepts embedded in them. By letting his students to figure out themselves whether they are correct or not, or whether what they did makes sense or not, Mr. R. have created a classroom culture in which students' reasoning become explicit, are welcomed, and are expected. The ways in which students reason and think about a given mathematical situation are crucial for teachers to know because, based on constructivist theories, students' existing knowledge and ways of thinking shape their current learning. Even if a student gives a correct answer to a question, the meanings and understandings that the student holds should be known to teachers in order to promote conceptual development (Anthony & Walshaw, 2009). This way, teachers can pose questions that may trigger a cognitive conflict in their students, who in turn may start re-evaluating their existing understandings. Simon et al. (2004) suggested a conception based teaching approach that focuses on identifying students' current understandings, articulating crucial desired understandings within students' process of conceptual development, and designing activity sequences that help them attain the desired conceptions. We saw evidence that Mr. R.'s well designed computer activities fit with the above description of Simon et al.'s approach.

We have also identified these classroom processes of hypothesizing, reasoning, explaining, and making sense as higher order thinking because, as Mr. R.'s students manipulated information and ideas through these processes,

they engaged in meaningful problem solving and discovered meanings and understandings that were new to them. Furthermore, a certain level of uncertainty and less predictable instructional outcomes were also present in Mr. R.'s lessons, which seemed to have allowed 'freedom to explore.'

Mr. R. began the five day unit on geometric transformations by two short activities that lasted about ten minutes in total. He first displayed images of certain objects and asked questions that elicited his students' existing understandings about symmetry, reflection, translation, dilation and rotation. The images he displayed were real life objects: A butterfly and Mr. R's own face. Next, he took various student comments and answers and "revoiced" them by adding deep mathematical arguments about geometric transformations. In a sense, he told his students everything they needed to learn about all the concepts in this unit. After this engaging introduction that "hooked" students into the unit, Mr. R. "unpacked" the quick and deep mathematical arguments in many hands-on, computer-based activities within the next four days. Thus, Mr. R.'s five day unit on geometric transformations was an active inquiry into the big ideas of transformation. As discussed earlier, Mr. R encouraged different solution strategies and not focused on correct answers during the initial phases of making sense of one's own activity. He gave his students freedom to choose their own tools and encouraged them to evaluate their own thoughts. Therefore through these practices Mr. R have prevented the creation of a classroom culture where right answers represent understanding. Instead, we have observed a classroom culture of hypothesizing, reasoning, explaining, and making sense. By letting his students to actively manipulate the information embedded in the well-designed computer activities and reflecting on their actions, he allowed his students to transfer their meanings. This self discovery and cycle of 'action-reflection-

explanation-further action-further reflection-further explanation' is very different from passively receiving or reciting factual information or employing rules and algorithms through repetitive routines.

Mr. R was also focused on the affective engagement of his students. He continually gave positive reinforcement to students while pushing their thinking to new heights, or what we are calling affective press. He often told his students "I like that. That's good work. That's good reasoning." In these comments, he often focused on his students' effort and unique solution strategies, rather than whether they got the "right" answer. He was always in constant motion, telling students, who were working at their desks, "focus," "that's what I like to see," and "you've got to write something." He also continually reminded his students about the SOL test.

Discussion

It is important for the reader to remember that all the classes observed were middle-track classes that included students with IEPs. The practices of these teachers varied in a number of important ways, but are similar in that they organized instruction around concepts, held high standards informed by a strong understanding of students' zones of proximal development, and fostered a classroom culture that was focused on problem solving. Thus, rigor was not manifested as attention to only one of these factors, but a coordination of several factors at the same time. The case studies that spanned the school year indicate that rigorous teachers work to build a culture of rigor, with academic skills that support such a culture over the course of the year. The more in-depth single-unit case studies suggest that teacher effectiveness in helping students develop more sophisticated, disciplined conceptual understandings requires providing students with the opportunity to explore their pre-conceptions first, and test those conceptions against real world representations of the concept. In both the

math and economics units, students were encouraged to try out different approaches to solving problems that arose. This led to students taking ownership of the learning, and provided an incentive for them to change how they might approach their assigned tasks (Glaserfeld, 1995).

Teachers in this study, consistent with expert teachers discussed in education literature (Wilson & Wineburg, 1988; Stemhagen, Reich, & Muth, 2012; Stigler & Hiebert, 1997), organized instruction around conceptual understandings, rather than around discrete bits of content. Content, in this sense, was a means to an end. Without content, concepts are just maxims, and are unlikely to be understood. Content was used by the teachers to provide examples that gave concepts their form. Although none of the teachers mentioned it specifically, this practice of designing instruction at the unit level around conceptual understandings is consistent with the suggestions of Wiggins and McTighe's (2006) *backwards design*.

Curricula designed in this way shift the burden of making sense of big ideas from the teacher to the students. Throughout these examples, students were not taught about concepts, they were provided content-rich experiences in which they *uncovered* (Wiggins & McTighe, 2006) these concepts. The teachers explained that they came to this understanding of curriculum design through trial and error. For example, in previous years, Ms. Zweibel had given her students a list of economics vocabulary first, then engaged them in the process of starting a business. She found that the vocabulary was not being learned very well this way and decided to introduce specific vocabulary words when they came up in the process of starting a business. Some of these vocabulary words were concepts, others were not, but they were introduced when they described something that students were already working with.

Mr. R.'s symmetry unit began with students

exploring the concept and articulating their own understandings of symmetry in the natural world. He began this discussion with his own face and moved on to butterflies. In order for Mr. R to help his students adopt more powerful mathematical understandings of symmetry, he had to listen to and interpret what they were saying and doing when solving mathematical problems; and then build models of their thinking. This was evident when he asked students whether his face was symmetrical and then had them explore natural shapes using Geometer's Sketchpad. Mr. Smythe noticed that his students struggle with SOL multiple-choice questions involving sequencing, and he responded by making sequencing a big idea that helped organize instruction throughout the year.

Rigor describes the way in which these educational designs were put into practice; but it did not emerge as a consistent descriptor. In other words, there was quite a bit of variation in the ways in which rigor was manifested in these classrooms. The teachers were confident that students could do the work, because they assessed students in a variety of ways and over time; teachers had a rich evidence base that indicated what students were capable of. These teachers used academic press in different ways, which seemed to depend on a mixture of the teachers' personalities and their students' needs. Both Mr. R and Mr. Smythe used what we have termed, affective academic press. They built an *esprit du corps* among their students, and exhorted them to try, giving frequent positive feedback that paid particular attention to effort and strategy use, as opposed to the "right answer." Mrs. Zweible, on the other hand, focused her students on their personal responsibility for completing assignments. It is worth noting that Mr. Smythe taught 6th graders in a high poverty school and Mrs. Zweible taught 8th graders in a low-poverty school. This is not to say that demographic differences should define one's approach to academic press, but teachers who

are good at it, appear to be sensitive to student needs.

Academic press and backwards design by themselves are not enough, however. The assignments that these teachers gave were engaging. Students were active in all the observed lessons. They were doing things, often together. In many of the lessons there was even an element of play such as in Mr. R's geometry class where students manipulated images of faces and butterflies to explore the concept of symmetry visually before being introduced to some of the mathematical representations of symmetry and their related computations. Too often, we observe that these types of activities are seen as an "extra" or "enrichment" that can be attempted with the faster students *after* the factual content is taught and learned sufficiently. On the contrary, Mr. R. begins with these activities to hook students' interest, and to introduce them to key concepts using examples from the world outside of school. Thus, all of his students are always engaged in meaningful activity throughout the unit.

Finally, the observations that spanned the academic year indicate two important findings that are not discussed much in the literature on teaching and learning: 1) rigor looks different at different points in the school year; 2) collaborative learning experiences require months of preparation in inter- and intra-personal skills; and 3) helping students to think in powerful disciplinary ways requires sustained attention from the teacher across the school year. Thus, rigor evolves over the course of the year as students develop and become used to the skills and expectations the teacher demands. Had Mrs. Zweibel attempted her big project in October, it is likely that the results would not have been as powerful. Students would have been less used to working with each other, and less used to Mrs. Zweibel's demands. Mr. Smythe's students were learning how to work together throughout the year. Although he did not do a big PBL project like Mrs.

Zweibel, his students were able to engage in longer and more academically difficult collaborative activities in April than they were in October. Mr. R.'s students come to him with the understanding that math is about finding the exact right answer, rather than an exploration of possibilities, and an exercise in both creative and logical thought. In other words, teachers had to dedicate a lot of time and patience to helping students *unlearn* some ideas about doing school that they had learned through previous experiences.

Concluding Remarks and Suggestions

Encouraging teachers to teach with greater rigor, as we have defined it, will not be easy, nor will it happen overnight. Many factors that are part of the day-to-day practice of classroom teaching render such changes difficult. However, we have observed that with continuous reflection, lesson revisions and effective use of tools, rigorous teachers do build an effective teaching practice over years of experience. Mr. R.'s effective use of computer software programs, which were refined over many years of trial and error, have significant impact on students' learning of geometry: his lessons are structured through engaging computer activities that sustain students' focus on important geometry concepts, and his students are actively manipulating the information embedded in the activities and reflecting on their actions. This self-discovery and cycle of action-reflection is very different from passively receiving or reciting factual information or employing rules and algorithms through repetitive routines.

We suggest that both experienced and inexperienced teachers may have rich opportunities for professional growth if they are given the chance to encounter current research on learning that is specific to the ways in which learning occurs in

the different disciplines (e.g., math, history, science, etc.). Our literature helps to define what big disciplinary ideas are, and explores both the conceptions and misconceptions that students bring to the classroom. Rather than containing the answers to the pedagogical problems, this literature provides a conceptual structure and examples from practice that can help teachers reflect on their practices and their students' learning, which may lead to real improvement in practice.

The passion that we have seen among school leaders for problem-based learning (PBL) is very heartening. We applaud the enthusiasm but we'd like to caution that there will be bumps in the road to greater use of this approach. In their passion for PBL, for example, teachers may try projects that demand too much in regards to collaborative skills early in the school year. Just as reading skills develop throughout the year, collaborative skills develop as well. Neither reading nor collaborative skills are likely to develop, however, if teachers are engaging students in them in the Fall. The issue is one of scaffolding, and it will require some trial and error over the course of entire school years for teachers to learn how to gauge what skills to build and when to focus on them.

Recommendations

Rigorous teachers:

- ◆ Are really sensitive to the struggles that students have in understanding these concepts – this sensitivity leads them to periodically re-design their instruction.
 - ◆ Think in terms of the big ideas that they want students to understand.
 - ◆ Design their instructional practice in such a way that their students shoulder some of the burden of *uncovering* these ideas, rather than them just telling students the ideas.
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- ◆ Design units rather than free-standing lessons.
- ◆ Create an ambiance of rigor through applying academic press, which may look different in different school contexts.
- ◆ Use activities that are fun and engaging; and different things happen in the classroom in any given period. [All of these teachers described in their interviews how they began by trying to find engaging activities and that these activities evolved as they worked to connect them more deeply to big ideas in the discipline.]
- ◆ Use ambitious project-based learning, and even ambitious collaborative classroom activities lasting 20 minutes or so. [The observations that occurred over the course of the year made it clear that ambitious project-based learning, and even ambitious collaborative classroom activities lasting 20 minutes or so, require months of preparation in inter- and intra-personal skills. Thus, what rigor looks like changes over the course of the year as students develop and become used to the skills and expectations of the teacher.]

Policy Recommendations

Rigorous teaching is strong amongst particular teachers. How can the expertise of these teachers be leveraged to improve others?

- ◆ Teacher leadership – particularly rigorous teachers may enjoy stepping into a mentorship role. We suggest that districts experiment with teacher-leadership structures that keep teachers in the classroom but offer course and assigned duty releases so that they can spend part of their day mentoring other teachers. We believe that teacher mentors would benefit from PD on how to be a teacher mentor. For example, the VCU Center for Teacher Leadership supplies such training. We could work with them to offer

training that is enhanced by this research in that it focuses not just on pedagogy but curriculum design: discovering big ideas in the SOLs, designing units around such big ideas, focusing on building student academic skills over time.

- ◆ Teachers attempting new and more rigorous pedagogies *will* experience failure. We have found that rigorous teachers built classroom cultures that accept failure in the pursuit of knowledge. How can districts encourage such culture among teachers? Without concrete moves in this direction, teachers will have an incentive to teach unambitiously, or even defensively.
- ◆ Effective professional development toward rigor should seek to replicate the processes that these successful teachers went through on their journeys through ambitious, rigorous practice. Focused Inquiry and Professional Communities of Practice groups can be a way to efficiently and cost-effectively deliver this professional development (McLaughlin & Talbert, 2001; Seashore-Lewis & Cruz, 1995). This work can be particularly useful if it is focused on:

1. Unit design
2. Assessment
3. Evaluating student work

Teacher-led groups that engage in these processes together give teachers the opportunity to discuss practice in-depth. A focus on assessment and student work provides real evidence of whether goals are being met. This evidence can be used to refine practice, unit design, assessment design and the student-achievement goals themselves. In mathematics education, "lesson study" could offer a powerful professional development to accomplish this.

Education professors, such as ourselves, can also be useful in this process. We can act as facilitators

of teacher communities of practice, and as resources with regard to educational research. We are steeped in this research, and we create and consume it daily; and we possess deep knowledge of our disciplines.

¹High-stakes accountability policies refer to policies that apply decisions with significant sanctions for educational stakeholders who fail to achieve an educational standard (Heubert & Houser, 1999). For students, high-stakes decisions are those that relate to academic-track placement, grade promotion, and graduation (Heubert & Houser, 1999). Under No Child Left Behind, sanctions can also be applied to schools whose students do not achieve at acceptable levels. The most serious of the sanctions that can be imposed upon schools is the mandated closing of a school and re-opening it with new leadership and staff. Test-based accountability refers to high-stakes accountability policies that rely primarily on standardized tests as measures of educational effectiveness (Hamilton, Stecher, & Klein, 2002).

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