Creating and Sustaining a Culture of Numeracy in Our High Schools

Alternative High School Initiative

Eighth Draft

Context

Tremendous controversy has stormed the nation's high schools over the teaching and learning of mathematics in recent years. Report after report points to the poor performance of high school math students. National Assessment of Educational Progress (NAEP) results for 12th-graders in 2005 show that only 23% of students score at or above the "proficient" level and 39% perform "below basic." Program for International Student Assessment (PISA) results indicate that U.S. 15-year-olds rank 28th out of 40 countries in mathematics. When U.S. data are disaggregated, the persistent gap between white and Asian students on the one hand and black and Hispanic students on the other remains stark and unacceptable (Johnson & Kritsonis, 2007). Moreover, as many as one-third of all students who enter college must spend additional time and money taking remedial courses that cover major parts of high school mathematics (Greene & Winters, 2005), even parts these students had already "learned."

Policymakers have sounded the alarm: This poor performance threatens our standard of living, our economic viability, and the democratic foundations of an informed citizenry. Millions of dollars have been spent on initiatives to reverse these trends. Such initiatives generally aim at the obvious targets—mathematics curriculum and instruction and accountability systems—and employ strategies that primarily intensify current practice. Students are pushed earlier and in greater numbers into "college-preparatory" mathematics courses, while math courses that deviate from the "march to calculus" are eliminated. States have steadily increased high school math course requirements; California now requires every 8th-grader to take Algebra 1. As the number and frequency of high-stakes tests have burgeoned, the consequences of poor test results have become more devastating for teachers, students, and schools. The brave curriculum reform projects to promote deep mathematical understanding and application that gained prominence in the 80's and 90's are today being scaled back. Instead, private and public resources now flow into supplementary programs with the narrow goal of boosting standardized mathematics test scores.

Some of these initiatives undoubtedly will raise student test scores. Even so, it would be naïve to believe the problem has been solved. Low test scores are merely a symptom of a broader epidemic of mathematical impoverishment that permeates society. Large numbers of adults and children lack the basic mathematical skills and concepts needed to make informed and productive decisions at home, in the workplace, and in civic duties. Some have a real phobia of mathematics, and many, perhaps defensively, dismiss mathematics as irrelevant to everyday life. Despite the public frenzy surrounding

our students' poor mathematical performance, many adults admit freely—even with bravado—that they are personally "no good" at math. Many students find school mathematics intimidating and/or unrelated to their lives (except as a "ticket" to college), and many adolescents rule out majors and careers in scientific and technical fields because of the math course requirements. This "leakage" from the Science, Technology, Engineering, and Mathematics (STEM) pipeline would be less worrisome if it corresponded to intellectual potential, but evidence suggests this is not the case: The disproportional filtering out of students from certain minority groups and (in some fields) females suggests that potentially talented scientists and engineers are being eliminated for less valid reasons. One culprit may be the narrow way mathematics is taught, which appeals only to a small subset of students and fails to represent the dynamism, creativity, and problem-solving nature of mathematics in STEM workplaces. Finally, increased high school mathematics course requirements have been accompanied by skyrocketing failure rates in these courses and, as a result, increased dropout and delayed graduation rates (Silver, Saunders, & Zarate, 2008; Steen 2007).

This broad and growing pattern of mathematical underachievement illustrates that most policy responses have been misguided and, at best, have only treated the symptom, not the underlying epidemic. In this paper, we—educators belonging to the Alternative High Schools Initiative (AHSI)—present what we believe is a more effective and valid response: to build, nurture, and sustain a *culture of numeracy* in our high schools. We regard numeracy as "the capacity to bridge the gap between 'mathematics' and 'the real world', to use in-school mathematics out-of-school" and consider people to be more or less numerate based on "how well they choose and use the mathematical skills they have in the service of things other than mathematics" (Willis 1998, p.37).

To develop numeracy in all students requires not just changing the mathematics classroom but reshaping the culture of the entire school. The culture of numeracy we envision involves every adult and student in a school and therefore has tremendous power to create equity. This culture is highly personalized, inquiry-based, student-centered, and meaningful. This culture focuses on effective problem solving and values communication. It is a culture of relevant mathematics content, effective and participatory instruction, and high-quality and aligned assessments. Establishing such a vibrant learning culture requires a commitment by the members of the AHSI to capture our collective voice, to influence our school communities to work diligently towards this culture, and to reach consensus on a set of meaningful numeracy principles that will help our students lead powerful and productive lives.

To these ends, this paper articulates a culture of numeracy and how AHSI school communities can establish and sustain one.

Numeracy

Numeracy can be defined as a set of proficiencies developed not only through the study of mathematics but also through the study of other disciplines and through out-of-school experiences. Numeracy is more than the ability to do basic arithmetic. It involves developing confidence and competence with number and measure. It requires an understanding of the number system and operations, a repertoire of mathematical techniques, and the inclination and ability to solve quantitative or spatial problems in a range of contexts. It demands a grasp of the ways in which data are gathered by counting and measuring, and presented in graphs, diagrams, charts and tables. And it includes fluency with mathematical language and the ability to use it appropriately to communicate about quantities in everyday life.

On an abstract level, numeracy connotes a familiarity and confidence with notions of change, chance, quantity, shape, and dimension. At a more practical level, numeracy entails proficiency with the skills and concepts of arithmetic operations, estimating results, assessing the reasonableness of answers, using measurements, reasoning proportionally or nonlinearly, and applying mathematical functions to real world phenomena—all critical skills of the workplace and effective citizenship. Numeracy applies in myriad domains, including:

- money management and financial planning
- personal and family budgeting
- understanding costs and benefits of social policies (e.g., going to war, a new gas tax)
- planning travel (e.g., reading timetables and maps, calculating distances and journey times)
- interpreting the news (e.g., grasping information in graphs, charts, and tables)
- understanding and generating sports statistics
- making environmentally sound decisions (e.g., “paper or plastic?”).

How is numeracy different from mathematical proficiency? Clearly there is overlap, with mathematical skill and understanding forming the core of both. But where mathematics education generally aims for algorithmic mastery, knowledge of mathematical facts and definitions, and an

understanding of abstract concepts, numeracy reflects a recognition of and fluency with the use of basic mathematics in everyday life and work. A loose analogy can be drawn to the contrast between literacy (numeracy's partner) and the study of literature or grammar (counterparts of the traditional mathematics curriculum). Learning to factor longer polynomials and integrate increasingly complex functions represent growth in mathematical proficiency but are unrelated to the development of numeracy. Instead, numeracy development is better characterized by the ability to estimate percents of prices with increased precision through more sophisticated, internalized strategies, or by a deeper understanding of (or "feel" for) the magnitude of 6 billion people and how that compares to the population of France, or by more valid predictions about whether certain real-world variables should be related linearly or otherwise. This sort of development *can* happen in a high school mathematics class, but it will not automatically; it requires the significant incorporation of nontraditional tasks outside the standard curriculum.

Importantly, the goal to build numeracy in today's high school students embodies the most recent understandings of how to prepare students for 21st-century life: Students should develop global awareness, along with financial, economic, business, and entrepreneurial literacy, and civic literacy, through interdisciplinary learning emphasizing problem solving in real-world contexts (Partnership for 21st Century Skills, 2007).

Teaching and Learning

A powerful learning culture is critical to the success of any curricular program. Traditional mathematics classrooms often leave far too many students behind—in preparation for both advanced mathematics and application in life—convincing them (usually for all the wrong reasons) that they are not fit to do mathematics. A visit to the typical traditional high school math class helps explain how we "lose" these students. We see the teacher at the chalkboard, overhead projector, or computer, demonstrating her own mathematical prowess by presenting example after example of the algorithm at hand. The classroom is chock-full of disengaged students neatly lined up in rows, each with their 700-page textbooks open and ready to "receive" the lesson. Students are expected to remain quiet and focused while copying the examples from the board into their notebooks. Abstract concepts such as percent, slope, polynomial, and geometric proof are "taught" with little or no respect to students' prior experiences or backgrounds. There is rarely room for inquiry or discussion about how these concepts are used in the world in which the students live, sometimes because there is "too much to cover," and

sometimes because what gets taught truly has little real-world relevance. As the lesson drones on, students wonder, “When will I ever use this stuff?” If they bother to ask why this content is important, the beleaguered teacher answers, “For next year’s math class,” or “Because you’ll see problems like these on the test.”

Nearly every lesson (except for frequent testing days) follows the same pattern: lecture, model, practice—all crammed into a 52-minute block of time. Procedure is emphasized over meaning; the material is fragmented, abstract, and unconnected. Instead of learning to think for themselves, students become dependent on the teacher and demand, “Just show me what I need to do.” The teacher ignores any student expressions of dislike or fear of math, feelings that are only reinforced by the unresponsive lesson format. The students, unclear about the reason and value of the lesson, slide further and further into their desks and into despair. Even for the most conscientious students, who study the material every night and dutifully complete the assigned exercises, the concepts never solidify—in memory or in understanding—and they see little or no relevance or connection to other disciplines. After days of this process, students take “the test” to measure whether or not important concepts were “learned.” The test is graded and many students “fail.” Yet the same didactic approach to procedural knowledge is repeated the following day.

The ways we fail our mathematics students, however, extend beyond the mathematics classroom. In the traditional school, the 52-minute algebra class ends and the students leave the math classroom—and mathematics—behind. Out in the hallway, students catch up with friends and talk about TV shows, a new electric bass, trouble with a girlfriend. Teachers rush by, congratulating students on their performance in last night’s basketball game or complimenting a new haircut. Hallway showcases display student paintings and pottery, posters advertising the school musical, signs replete with text—lists of rules for respect, school policies, bulletins for upcoming events—but few numbers and nary a graph or pie chart. Students arrive in their next class, American History, where they become engaged (or not) in a lesson about World War I that is devoid of reference to matters of quantity. Basic mathematics could be used to investigate the size or duration or probability of many wartime phenomena, which would deepen students’ understanding of their impact. But the teacher passes on these opportunities, as is no surprise to the students, who have heard this teacher declare himself “not a math person.”

Of course, this portrayal of classroom and school is extreme. Few teachers are completely didactic and unresponsive to student needs, backgrounds, and emotions, and few school staffs and programs are so strictly compartmentalized. On the other hand, virtually all teachers and schools fall back on these methods and structures, at least sometimes, even when personnel are committed to improvement and responsiveness. When the intellectual, social, and emotional needs of mathematics learners in a traditional setting go unnoticed or unaddressed, it is rarely because teachers and school leaders don't recognize these needs or care. Oftentimes, unresponsive teaching is driven by the rush to cover content standards, prepare for exams, and meet Annual Yearly Progress quotas. And didactic, fragmented methods reflect how we were taught to teach and are what students and their parents expect from teachers. Moving away from traditional methods and divisions of labor is a difficult and uncertain process that requires solidarity—support and commitment from the entire school community. It requires a faith that more students will learn mandatory mathematics content when classrooms become more student-centered, inquiry-based, and related to life (Thomas, 2000). It requires adults in the community to recognize the damage they do when they say to students, "I'm just not good at math," and imply that this is an acceptable condition. And it requires a belief that all students can and must become numerate and that all community adults are responsible for helping—that numeracy is everybody's business.

Classroom Culture

What does a classroom that values and embodies a culture of numeracy look and feel like? First, students are aware of a guiding belief that numeracy is important for and accessible to all of them, that numeracy pervades everybody's lives and learning, and that failure to develop numeracy is not an option in this classroom. These beliefs are supported by an interdisciplinary approach that emphasizes the interconnectedness of mathematical topics among themselves and with other disciplines, demonstrating to students that math and numeracy are everywhere, not restricted within the four walls of the math classroom. English teachers refer to statistical evidence and discuss its meaning and usage to help students learn to write persuasive essays. History, social studies, and civics classrooms analyze the effectiveness of the billions of dollars spent on military endeavors, using funds dedicated to education as a point of comparison. Science courses, especially the cores—physics, chemistry, and biology—are permeated with and dependent upon mathematical principles; teachers of these subjects delve into the mathematics of acceleration, genetic outcomes, micro- and macroscopic measures of quantity, etc. In all subjects, students are encouraged to pursue and participate in engaging

"quests" where they can explore questions of personal interest, such as: *What trends do I see in teenage pregnancy? What numerical information can I collect to compare and contrast cell phone plans? What predictions can I make about the future cost of gasoline? Can I accurately project profits for one hip-hop recording company versus another? When does estimation suffice and when is precision a necessity when it comes to the practice of medicine? How can we weigh the costs against the benefits to society of providing free health care to all U.S. citizens?* In short, students are expected and encouraged to look for and apply pertinent mathematical concepts, tools, and techniques for the purpose of enhancing and enlightening their personal learning journeys.

Evidence that classrooms are promoting a culture of numeracy includes student-driven projects and work; the consistent request for justification and evidence for statements, hypotheses, findings, and conclusions; real-world problems with multiple solutions; and an emphasis on relevance and the learning of mathematics for life. Teachers make essential curricular adjustments and modifications for students, particularly for students in underserved groups, who are increasingly labeled learning deficient. Oftentimes this means asking students to work in small groups, allowing students to explore numeracy concepts that are important and relevant to them, and creating small, individualized tasks that focus on process as much as on getting the "right" answer. Further, a strong classroom culture of numeracy does not allow students who are fearful or math-phobic to fall through the cracks. By supporting and encouraging positive student dispositions and attitudes towards all things mathematical, teachers can help students gain the confidence necessary to succeed. The human mind is a mix of social, emotional, and cognitive processes that overlap and offset one another. Providing a foundation of confidence allows and facilitates students to take risks, to ask questions, to think independently—all processes leading students to reach new levels of success. Cognizant instructors value these essential components of the human mind. By listening purposefully to students, teachers conduct both formal and informal check-ins, nurturing the successes and identifying challenges (Morony, Hogan, and Thornton, 2004). This communication between the student and staff is a continuous process because students' past experiences and learning challenges are multi-layered. Providing students with clear expectations and belief in their success is a crucial element in building a vibrant culture of numeracy.

School Culture

A rich learning environment with an interdisciplinary focus that respects students' intellectual, social, and emotional development is the heart of a strong school culture of numeracy. Schoolwide

communication that is persistent and emphatic is foremost in guiding the school community to understand and embrace the central role of numeracy. There are regular "celebrations" of all aspects of student work and an emphasis and appreciation that both process and products, not just the "right" answer, are deemed valuable. Throughout the school, evidence of this concentrated focus on numeracy can be found in newsletters, school web pages, and posted student work. Visitors to the school are quick to feel and see that the teaching and learning of mathematics is important and serves a real purpose and meaning.

In a school that promotes and values a strong culture of numeracy, a fundamental belief exists among the members of the learning community that students can and will succeed in learning and applying a variety of mathematical tools and techniques. Because the understanding of math is crucial to the future success of the students and the school, this belief system runs deep through the community. To meet the challenge of ensuring that all students achieve numeracy, it is understood that numeracy is everybody's business. School leaders take initiative by supporting students' interests around mathematics and embrace numeracy principles with transformative language that inspires and motivates. All school personnel use mathematical language, speaking about number sense, percentages, ratios, proportions, and data analysis, which promote student fluency and familiarity with such terms. This use of mathematical language by staff is not limited to discussions of math education. Adults in the community model numeracy by discussing with students their own use of mathematics in everyday endeavors, for example, when a teacher explains to a class why he decided to refinance his home, or a coach explains why she feels that a better way to characterize players' abilities in vertical jump is to use the mode of all their measurements rather than the mean. Overall, a positive whole-school environment coupled with an extended community that is nurturing and supportive ensures that all students gain access to the mathematical tools and skills necessary to be successful in life outside of school.

Guiding Principles

We at the Alternative High School Initiative identify the following principles to be of the utmost importance for effectively building a culture of numeracy in our high schools:

- **Numeracy, along with literacy, is a co-equal building block of human intellectual prowess.**
- **Numeracy is everybody's business and pervades a school's culture.**

- **All students can and must develop numeracy skills and dispositions and become powerfully numerate.**
- **Numeracy cannot be developed solely by learning mathematical procedures; these must be embedded in guided, open quests, explorations, and investigations.**
- **Numeracy connotes a familiarity and confidence with notions of change, chance, quantity, shape, and dimension.**
- **Real-world relevance and connections—both cross-discipline and within mathematics—are the cornerstones to developing numeracy skills.**
- **Numeracy requires effective communication, both written and oral.**

Implementing these guiding principles entails steep challenges. Deliberatively building such a culture of numeracy involves uncertainty. Forging new and untried pathways creates uncertainty about the effectiveness of strategies, about the types of resources that are needed, and about both short- and long-term effects on students' lives. We must face this uncertainty with courage and purpose, with a determined focus and understood ability to direct the course of learning that fully embraces the guiding principles outlined above.

Taking Action

We have identified our guiding principles and articulated what we value in regard to creating and sustaining a culture of numeracy. But how does a school community begin to accomplish these things and how does it know when it has arrived? Here are some steps:

1. Talk to people in your community about the ideas presented in this paper.

2. Post and regularly refer to the numeracy principles listed in this paper.

3. Ask students to talk and write about their mathematical experiences, in classes and in their out-of-school lives. These experiences should include not only situations where students used math or saw the importance of math but also their feelings and opinions about math. Part of creating and sustaining a positive math culture involves addressing the current culture, which often includes negative or dismissive attitudes. Listen to your students; their ideas have been formed in response to academic and

social practices they have grown up with, and validating and understanding their responses is necessary in determining how to effect changes.

4. Take a "math walk" on which students discover the natural math all around them.

5. Pose a school-wide thematic question every month such as, *What is the real cost of energy?* In classes across disciplines, students can use quantitative reasoning and data as well as disciplinary skills and facts to answer the question from various perspectives.

6. Post samples of student work that demonstrate high levels of rigor and relevance in quantitative analysis.

7. Identify the professional development required to create these school and classroom cultures of numeracy, and then strategically act to implement this professional development. This must include building awareness in some staff members of the importance of numeracy in everyday life and across subjects. Staff "math walks" and mathematical autobiographies are excellent strategies for bringing about this awareness. Time must be allotted for teachers in same-subject and cross-subject groups to meet and explore ways that numeracy intersects with the material they are required to teach. Time and space should be devoted to collaborative lesson and project design, where math teachers may serve as group leaders to help infuse quantitative concepts and skills. Development should include other members of the school community, including parents and workplace mentors, so that the culture of numeracy extends into the students' homes and internships.

8. Routinely ask self-evaluative questions about your development of a culture of numeracy. These could include:

- Where do we see regular evidence of the guiding principles in our schools and our organization?
- Are some of the guiding principles more apparent than others? Why might that be?
- What obstacles do we face in moving toward their full implementation? Will this require significant changes in our current practice?
- Has there been resistance to change from teachers, the district, and the community at large? How have we addressed that resistance? How can we do so more effectively?

9. Develop “numeracy teams” in your school to serve as “critical friends” who can visit classrooms, the library, the cafeteria, and other school spaces, and whose goal is to uncover and communicate the places and situations where numeracy exists and to stimulate conversations with students and staff about developing and strengthening a culture of numeracy.

10. Conduct school-wide scans and audits to identify opportunities to develop numeracy or create opportunities where they don’t exist.

Conclusion

Creating a culture of numeracy, like any school restructuring effort, is deeply challenging. No teacher can accomplish it alone, nor can independent and divided efforts behind classroom doors. A whole-school approach to building a culture of numeracy amplifies individual efforts, creates a common vision, and unites the community through a collective voice. Students, teachers, parents, and others involved in the learning process all possess the potential to re-energize the AHSI network through a rigorous commitment to improving numeracy for all. By clearly defining our collective vision and reaching consensus on the ideas presented in this paper, the AHSI network will move closer to achieving what standardized testing and state and federal regulations dream of: students who appreciate and understand the value of mathematics, who know when numeracy skills are needed to solve real-world problems, and who successfully use math to make informed decisions, to interpret and evaluate data, to solve quantitative and spatial problems—in short, to be fully and confidently engaged in the numerate world around them.

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