Students’ Mathematical Beliefs Implicitly Learned through Assessment

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Abstract

Students come to beliefs about what mathematics is through a host of factors. One of these is through the way that they are assessed. Through summative, standardized achievement tests, students are evaluated on what it is they know in mathematics. The resulting evaluation tells students how well they learned the material. The grades they get let them know how “good” they are at math. And yet, this is not necessarily true. Assessments do not fully evaluate students’ mathematical knowledge. Assessments fall short of this, especially in the vision of mathematics that reform movements are calling for. And as students continue to take tests throughout their years in public schools – as they take tests to go to be placed in advanced or remedial classes, tests to enter into college, or to simply just pass their current class – they come to implicitly learn what “counts” as knowing mathematics. Students have come to believe that math is about following rules, answering quickly, and getting the right answer. Interestingly, reform mathematics calls for a shift away from all of these things. However, these reform movements are struggling to take hold in a society that has attached even more high stakes to tests – tests that still reward rule following, answering quickly, and getting the right answer. This paper looks at what reform mathematics calls for and juxtaposes this with what students come to believe about mathematics through assessment. It ends with a discussion of what an alternative, reform mathematics assessment might value and what all of this means for my practice as a teacher.

Keywords: Mathematics, Assessment, Student Mathematics Beliefs, Mathematics Epistemology, Reform Mathematics

Students’ Mathematical Beliefs Implicitly Learned through Assessment

In 1995, R. E. Stake wrote “standardized test scores are not … a sound basis for indicating how well students are becoming educated in mathematics” (p. 173) - the mathematics community I have aligned myself with stands firm in this statement. The knee-jerk reaction would be to ask what was wrong with the tests and how we might change the tests so that students are better evaluated on their mathematical ability and mathematics knowledge. We adopt new tests all the time in hopes that they will better evaluate our students. What is less common is the question: what mathematics are we assessing?

 The ways we view math and the ways we teach it are constantly evolving. And as stated, the current dominant form of mathematics assessment in public school remains inadequate in its goal of determining students’ mathematical understanding. Current trends in theories of knowledge and education reform work together to create a vision for mathematics. However, that vision is disjointed from the dominant form of assessment. And through this assessment, students are coming to beliefs about what “counts” as knowing, or being good at, mathematics.

This paper takes a look into how students are coming to define what mathematics is through how they are assessed. Assessment is not the only way in which students come to have mathematical beliefs – it is a relationship between a host of factors such as instruction materials, how those materials are implemented, teacher beliefs, etc. (Aiken, 1976). However, assessments do tell students a lot about what “counts” and what kinds of mathematics is valued.

We have perpetuated the belief that the assessments measure how much of the material one knows. To prove this, all one needs to do is look at the importance of tests in: a syllabus, the time taken out of the year for standardized testing, the allocation of funds based upon assessment, the implications of failing to make Adequate Yearly Progress, exit exams for passing a class or graduation, etc. – tests are important and correct answers are how students show what they know. With this belief, students think their mathematical knowledge and ability is directly tied to their test scores.

In this Capstone, I write about the tension between what we are explicitly telling students mathematics is through policy and epistemology, and what students implicitly learn what matters through assessment. This Capstone focuses on three professional knowledge areas: the learner (students), the learning context (public school – particularly, high school), and assessment (summative, standardized achievement tests). I begin by briefly detailing these three knowledge areas. Then, I review the literature on the tension mathematics as a field faces in conceptualizing and implementing a vision for mathematics. To do so, I briefly discuss the reform movement in both policy and then go a little more in depth on mathematics epistemology. Then, I focus on assessment in public school mathematics and the ways in which students may come to believe what mathematics is based upon what assessment is implicitly telling them what “counts.” After this tension between assessment and the vision of reform mathematics has been built, I assert alternatives and discuss some current ideas about how to assess student understanding. To end, I reflect on how this impacts my thinking and my practice as a future high school mathematics teacher.

# Professional Knowledge Areas

This Capstone uses a situative lens to view not only mathematics, but also the learner and the ways that count as them being mathematically knowledgeable. This situated view comes from current trends in epistemology (see: Brown, Collins, & Duguid, 1989; Boaler & Greeno, 2000) and has implications for not only pedagogy, but also how we define and measure students’ subject knowledge. In particular, public high school classrooms are full of students who have spent their lives being told math is important and being told that the way to show that you are good at math is to get correct answers (NCTM, 1989).

Through the ways these tests pose their mathematics questions, procedural fluency becomes valued (Onwuegbuzie & Leech, 2003; Lockhart, 2009; Schoenfield, 1992; NCTM, 1989). Because of this, knowing facts and knowing them quickly becomes a distinct advantage in mathematics assessments. However, these facts (e.g. 1+0 is the identity property of addition) are not separate from the math practices (see: Common Core’s 8 math practices) a student takes up in the classroom. The assessments do less to determine how a student is thinking about a problem and more to do with how a student answers a problem. This can pose a problem for teachers who wish to use assessment *for* learning (Stiggins, 2002, 2005).

“Having mathematical tools does not mean knowing when and how to use them” (Sfard, 2013, p. 133). In Sfard’s argument, mathematical understanding goes beyond fluency with mathematical facts. It is also the ways in which students choose to use those facts. She goes on to make the distinction that “doing” mathematics is a combination of three things: being able to read mathematics, to come to an understanding (as opposed to already understanding) about mathematics, and to communicate mathematics. This reading and communicating of mathematics creates a vision of mathematics as discourse (Sfard, 2013).

**Learner**

The focus of this Capstone is primarily high school students as the learners. However, they are not the only ones learning about what “counts” as mathematics through assessment. Teachers, administrators, and the community at large also learn or have learned these same beliefs through similar tests. Assessment is not the only way students come to hold beliefs about mathematics. Other ways that students might form beliefs about mathematics are through the ways it is taught to them, through the curriculum and the way that curriculum is enacted, through the ways the subject becomes salient in out of school contexts – there are many factors that might influence a student’s mathematical beliefs. However, this capstone just focuses on the way assessment implicitly teaches students what mathematics is.

**Learning Context**

This is taking place in a time when what kind of mathematics is valued and what counts as being knowledgeable in mathematics is constantly being questioned. Through reform efforts, students are now expected to meet particular standards within a given time. They are assessed for that knowledge with implications for their future class placements, funding for the school, and teacher evaluation. While pedagogical reform efforts are constantly evolving, the ways in which we assess mathematical knowledge is not. The dissonance created from different values – what the classroom values and what the assessments value – gives conflicting messages to students about what it is they are learning. The context of the learning environment – the public high school – is during a time in which alternatives to assessments are relatively young in their conception and research into their effectiveness is equally as young.

**Assessment**

This context has clear implications for assessment. Summative assessment and standardized testing both generally are attempting to figure out what it is a student has learned – they are assessments *of* learning. Formative assessments are generally used by teachers as assessments *for* learning. Teachers use them to help them learn what students are understanding about the material. They are able to respond instantly and use this information to improve learning for their particular class of students. While formative assessments are used often by teachers, this Capstone focuses primarily on summative assessments and standardized assessments since these are generally the assessments that are tied to student grades, school funding, teacher evaluations, etc. Therefore, these are generally the assessments that “count.”

**Literature Review**

Students come to have very strong opinions of math. They love it, they hate it, they are good at it, they are bad at it – all of these beliefs guiding the way they perceive the subject (Fuson, Kalchman, & Bransford, 2005). If you were to ask any person who attended public schools what math was, they would be able to recall to you many different things that they did in class. They would most likely refer to math as the manipulation of numbers and shapes. People generally seem to believe they have a concrete idea of what exactly math is. Yet, it is interesting to note the sheer amount of dissonance in the language of policy, within the literature on mathematics epistemology, and the kinds of mathematics that is valued in our assessments.

**The Reform Movement**

In 1989, the National Council of Teachers of Mathematics (NCTM) issued a report calling for a reconceptualization of mathematics. In it, they note the rise of technology and assert that what was important mathematically before is quickly becoming obsolete. Where it was once important for even low-wage job workers to be able to do basic arithmetic (e.g. a retail store worker counting change), technology helps fill in the gaps in understanding and no longer requires that once necessary skill (e.g. cash registers can do it for them). The NCTM and Common Core (2010) both believe in a vision for standards-based instruction (see: Stein, 2009).

These standards were to be adopted by the states so that a common curriculum could be taken up nationally. If a student were to move from one state to another, they would still be learning similar things. This standards-based curriculum was implemented in a post-No Child Left Behind (NCLB) society. NCLB calls for schools to be tested and evaluated for improvement. Not only is funding tied to this improvement, but also school ratings and teacher pay.

There are many reform movements within public school education. Three of these (not an exhaustive list) are: 1) the role of failure as being productive and useful for learning (Kapur, 2010), 2) 21st century skills such as communication, collaboration, and solving problems in innovative ways are emphasized (see: Partnership for 21st Century Skills), and 3) inquiry-based, problem-based, and project-based learning that calls for students to learn through exploring difficult and complex tasks (Schoenfeld, 2013; Stein, 2009). These reform movements have also found their way into the mathematics classrooms.

**Vision of Mathematics**

Anna Sfard (2013) writes about why math is so pervasive in society – various reasons as to why we give it such import. In doing so, she sheds light on some different ways in which math is viewed. The four lenses are the utilitarian, the political, the cultural, and the “selection tool.” With the utilitarian view, math serves its function in its usefulness to us. Math is something we can bend to our will to serve our needs. In the political view, math serves as a form of power. To be able to present numbers, make an argument, override arguments, and to impose order on the world are assets that are key to success in political life. With this view, math empowers. Math allows one to move upward socially. In the cultural view, math is a discourse – or way of communication – and allows us to participate in a society.

The last view of mathematics – a “selection tool” – is her more controversial view of mathematics. In this view, math is used as a way of classifying people. Being good at math allows one access to college and careers while being bad at math restricts access to both – math as a gatekeeper. Schoenfeld (2002) calls it the “critical filter” and briefly discusses the economic impact it has on people in our society. Schoenfeld argues that math is a gateway to technological literacy and makes his point via the literature on technological literacy and its import on economic success in this technology-driven era. While Sfard says that this view can be deconstructed quickly, she argues that the very idea that this could even be asserted should make us stop and question our policies. Shoenfield is not so quick to dismiss it as just an idea. He takes it a step further and calls it a civil rights issue that requires urgency.

Disproportionate numbers of poor, African American, Latino, and Native American students drop out of mathematics and perform “below standard” on tests of mathematical competency, and are thus denied both important skills and a particularly important pathway to economic and other enfranchisement (Schoenfeld, 2002, p. 4).

Sfard’s article goes on to give an alternative idea of perhaps what mathematics could be. She discusses how mathematics, in this technological era, needs to be re-conceptualized. She argues for a change in what mathematics in public schooling should include and what it should focus on. She writes about how math should be viewed as a discourse. Math can be viewed as an art of communicating as well as a basic form of literacy – the same way we view reading literacy. The communication aspect of this view places import on the interpersonal ways we discuss and use math instead of solely the traditional intrapersonal. The basic form of literacy view focuses not just on how to do math, but also *when* to use it (Sfard, 2013).

**Mathematics Beliefs**

Schoenfeld (1992) sums up the literature on student beliefs, teacher beliefs, and societal beliefs on what it means to do mathematics. Students believe that math is related to being able to get the right answer and to do so quickly. Doing math means following rules and knowing math means remembering it. Students believe that math has one right answer and it is work that is to be done in isolation. The NCTM made the same claim about students’ mathematical beliefs (NCTM, 1989). This is complete opposition to the interpersonal vision of mathematics given by Sfard.

There is also an emphasis on speed on tests (NCTM, 1989; Schoenfeld, 1992). Schoenfeld cites his own research in which he asked students in a questionnaire how long they think it would take to solve a problem if they knew how to do it and he asked how long it would take them before they realize a problem is impossible. Students answered 2.2 and 11.7 minutes respectively. This is especially disconcerting, Schoenfeld writes, because students “will give up on a problem after a few minutes of unsuccessful attempts” (Schoenfeld, 1992). Students come to believe that speed is an indication of mathematical knowledge.

While this was more than two decades ago, it is important to note that many assessments of great import to students today – e.g. college readiness exams like the SAT and the ACT – still assess mathematics in a way that rewards speed. And while this Capstone is focused on the student and students’ beliefs, it is important to note the ways in which teachers’ and society’s beliefs play a role in shaping students’ beliefs. Teachers play an obvious role in determining how it is students are to be assessed throughout the school year. When focused on content coverage, quick, routine problems may be more efficient in helping students move along and cover large amounts of content.

Society’s beliefs play an important role in policy-making as well as guiding what reform focuses on. For example, both policy (NCTM, Common Core, etc.) and epistemology (Sfard, Schoenfeld, Muis, etc.) note the effect of the current technological era on mathematics and call for re-conceptualizations of what math should look like in school.

**Mathematics Assessment**

This Capstone opened with a quote about how standardized assessments do not reflect what it is students know in math. But how could this be? It seems counter-intuitive to think that good or bad test scores would not also indicate that a student knew or did not know the material. Is not that the point of assessment? To know exactly how well students are doing in a subject? One would think so – especially with the high-stakes that accompany standardized tests of today (access to higher level classes, student grades, college entrance, teacher evaluations, school evaluations, funding, etc.). While this may have been written over two decades ago, it sounds as though it could have been written just this year. And with this, Gresalfi (2009) warns:

Most discussions about mathematics education cite concerns with students’ demonstrations of mathematical competence: tests are reported in terms of levels of proficiency, schools are given score cards documenting their progress, and academic standards typically focus on content goals to be met. Although this focus on content is understandable, it is inappropriately emphasized at the expense of other aspects of learning in a time when the boundaries around what counts as knowledge and who is considered knowledgeable are being pushed and expanded beyond previous expectations (Gresalfi, 2009, p. 364).

Essentially, mathematics is not just content to be covered. With a situative lens, mathematical knowledge and competency also requires fluency with knowing when the content is valuable, to be used, or can be expanded upon. The NCTM currently promotes mathematical practices (i.e. dispositions) that are also important for mathematics education (see: NCTM, 1989; Common Core State Standards Initiative, 2010; Stein, 2009). None of this – the multifaceted vision of knowledge and the math practices – are currently assessed in dominant forms of standardized testing or standardized achievement tests.

Popham (1999) provides three major reasons for why standardized assessments have some inherent problems and why they do not measure educational quality. First, the large amount of knowledge and skills that children are supposed to learn is too large for any one standardized test. Secondly, the companies that make the tests are forced to make “one size fits all” tests. Since educational policies might not only look different from district to district, but from classroom to classroom, the tests might not reflect what is valued in one particular curriculum and in one particular classroom. Popham (1999) further underscores this problem when he writes: “standardized achievement tests will always contain many items that are not aligned with what is emphasized instructionally in a particular setting” (p. 3). Third, the tests should not allow us to make meaningful comparisons of students from such a low sample of questions. There is simply not enough data based on a single test.

Stein (2009), while not explicitly discussing standardized achievement tests, gives us further insight as to why these forms of assessment seem disjoint from mathematics reform. Early in her book, *Implementing Standards-Based Mathematics Instruction: A Casebook for Professional Development*, she gives a chart called “The Task Analysis Guide” (p. 6). The four types of tasks are: memorization, procedures without connections, procedures with connections, and doing mathematics. This book, sponsored by the NCTM, details that a task labeled as “doing mathematics” would require students to: do problems that cannot be solved in a rehearsed way, require students to explore mathematical relationships and concepts, decide which knowledge is relevant for the particular situation, and may cause anxiety due to the unpredictable nature of the solution process.

This vision for what a “good” math problem looks like is one that would not bode well on a standardized test – especially one explicitly tied to high stakes accountability for the student, teacher, and school. These types of problems call for students to “explore” mathematical concepts – not something that can be done within a time constraint. These non-routine, anxiety-inducing problems are what Schoenfeld (2002) documents are the types of problems students skip and give up on. In short, these types of problems – the only ones considered “doing mathematics” according to Stein (2009) – are not problems that would fit in our current assessment system.

Stiggins (2002) posits that we may be trying to find the answers to the wrong question. He claims that we are constantly trying to improve standardized tests’ ability to measure mathematical understanding. He asserts that this is perhaps the wrong focus – maybe the question should be: how can we maximize the positive impact of our scores on learners? A new question emerges: what are students learning from assessment and what would we like for them to learn? And, is there a way to use assessment as an opportunity to learn instead of just a static, end of year grade?

So what are students learning from assessment now? From a behavioristic lens, assessments give students a stimulus - a question - and expect a specific response to that stimulus - a right answer (Collins, Greeno, Resnick, Bernliner, & Calfee, 1992). Shepard (2000) phrases it: “High-stakes accountability (testing) teaches students that effort in school should be in response to externally administered rewards and punishment rather than the excitement of ideas”(p. 9; parentheses added). Through these assessments, students implicitly learn what “counts” as mathematics based on correct answers. But, that is all they have the opportunity to learn from these assessments. Since tests are at the end of the year, students do not have an opportunity to learn anything explicitly from these tests.  However, many researchers and mathematicians are calling for assessment to instead assess for learning and not of. In this view, assessment becomes a tool for future learning.

**Implications for Practice**

We are still focused on moving from what Stiggins (2002; 2005) calls “assessment of learning” to “assessment for learning.” However, I would argue that reform mathematics is also calling for assessment *as* learning. The problems are not separate from the learning process. The vision is that the problems are challenging and force students to think in non-routine ways and to think about the relationships of things they already know and have already learned. As they attempt to solve these problems – as they are being assessed – they are learning.

Reforms like these call for problems that go beyond assessing if students can get the right answer. In a traditional problem, students might learn through the process it took to answer that problem. However, they also might not. Even worse, they might learn something wrong about mathematics that becomes masked by the fact that they got the answer right (Erlwanger, 1973). A new vision for assessment would call for problems that make the process students would take more intentional (Stein, 2009). These types of problems would focus less on the final answer than steps the student would have to take to get that answer.

From personal experience and from the comments written online about Common Core (Strauss, 2014), the closest assessment gets to this vision is when they ask problems in the form: “Solve this problem using this particular method.” However, the NCTM (1989) and the Common Core State Standards Initiative (2010) both push back against this. Instead, they wish students to view mathematics procedures as tools and to pose questions (or a series of questions) that force students to question which tools – procedures – are most helpful in various contexts (Stein, 2009).

This focus on the process takes many forms. One of them is in the idea of “productive failure.” Kapur (2010) argues for the merits of productive failure and learning from mistakes. In fact, the math practices endorsed by the NCTM and by Common Core imply that failure is something to be embraced as an opportunity to learn. However, this is not how assessments frame failure. And this great opportunity to learn becomes squandered by the static grades of assessments.

This opportunity to learn through failure shows up in many current reform movements. Common Core (2010) calls for students to persevere in solving problems and not give up in a short amount of time just as Schoenfeld (1992) documented students did on problems that took longer or they failed at multiple times. The P21 framework for 21st century skills (2009) calls for students to solve unconventional problems in innovative ways – problems different from what they have learned. To expect that failure will not occur is naïve; to expect that it should not occur and then punish it when it does only informs students on what is being valued and devalued in the learning process.

Failure is not the only thing that is devalued. The way Sfard (2009) writes about math as a discourse – as a way of reading and writing the world, as a way of communicating, as a form of literacy – is not the type of mathematics that is assessed today. The only reading of mathematics students do is the problem and the only communicating they do is their answer. There is no “critiqu(ing) the reasoning of others” (Common Core State Standards Initiative, 2010) nor is there any real communication at all. The “world” that students are given an opportunity to “read and write” is an isolated world from any of their lived experiences. Mathematics becomes something found within these questions on tests and not within the world at large.

An alternate vision for assessment would include some or all of these ideas. It would focus more on the process than on the answer. It would ask questions or a series of questions that would force a student to make decisions *for themselves* about how to approach it. And when the ways they choose to approach it let them down, they would not be punished for it. This reformed assessment would instead encourage students to embrace their failure as an opportunity to learn.

And through this, assessment becomes less disjoint from the learning process. For before, students learned and then they were evaluated – two separate acts. Assessing and learning are a fluid and interwoven part of teaching students. Now, with a reconceptualization of assessment, assessing becomes so intertwined with learning that it is not just assessing for learning, it becomes assessing *as* learning.

This alternative type of assessment is not as hard to imagine as one might think. Gresalfi & Barab (2011) thoroughly detail an online mathematics game in which the problems given to students encourage them to learn *as* they go through these problems. The ways students read this world mathematically, the processes these students took, and the resulting conversations about the math involved all came from the ways in which this program assessed the students. As Stein (2009) would have argued, the tasks involved were “doing mathematics.”

This said, no assessment can fully capture all that a student knows and understands on a topic (Popham, 1999). Therefore, I struggle to believe that assessment for student understanding should be used in such a standalone manner. If understanding cannot be assessed, then maybe we should stop thinking that it ever possibly could (Stiggins, 2002). Maybe assessment should be viewed as one piece of a puzzle – assessment can be used as one part of figuring out what exactly it is a student knows. Or maybe we should quit relying on one assessment – or rather, one *type* of assessment – to gauge understanding. Perhaps it is time that we begin to think of the ways in which we can use all types of assessment – traditional standardized tests (multiple choice, fill in the blank, etc.), open ended assessment, portfolios, and even informal assessment – as a conglomeration to make a case for what it is a student knows.

Or maybe it is time to stop using assessment as a static evaluation of knowledge. Dominant theories of knowledge content that knowledge is constantly being shaped and formed by individuals. Perhaps it is time that standardized achievement assessments – in their pursuit to evaluate knowledge – become just as dynamic in their grading. Shepard (2000) writes about an idea known as dynamic assessment. In it, assessment is not postponed until the end of the year, but instead occurs throughout the school year. It also occurs individually for the student as well as a joint-enterprise between teacher and student. This interactive approach to assessment allows teachers to better understand student understanding and to plan and scaffold more targeted lessons. In this view, assessment has the potential to become a means for interaction, dialogue, and a way to make what is important to learn more explicit.

I would contend that this dynamic view of assessing could take another step further. To get away from the traditional view that an important part of being mathematically knowledgeable is being fast, evaluations could constantly be on the lookout for new evidence for understanding. As McTighe & O’Connor (2009) put it: “Classroom assessments and grading should focus on *how well* – not on *when* – the student mastered the designated knowledge and skill” (p. 5).

But as of now, this alternate view of assessment is not the reality. And students are not oblivious to the practices of the school. They are very adept at picking up on what it is teachers value, what tests value, and what it is they need to do to get the grade. It does not do the students any good if there is dissonance between what classroom success looks like and what assessment success looks like. The skill set to succeed in one does not necessarily transfer to the other, and this is not a good thing. This path only has one road – and that is not towards a healthy mathematical understanding for all.

**My Future**

Success on tests and mathematical understanding need not be mutually exclusive. In fact, this is the charge and goal of assessments in general – to be able to directly associate success on these tests and mathematical understanding. However, as has been discussed, assessments do not. And students learn this implicitly throughout their school years. And if they realize what is valued in class is not valued on assessments – that the process and understanding is not valued as much as the answer – then the high-stakes of the assessments will outweigh what the classroom values. As Gresalfi writes:

For example, a teacher might ensure that she praises students for sharing their thinking even when they are unsure of an answer. However, if in that system grades are assigned based only on the accuracy of final answers, rather than effort, such a change is likely to be meaningless (Gresalfi, 2009, p. 365).

So what is a teacher to do? Popham (1999) asserts a course of action that I believe is worth considering. First, become knowledgeable about the substance of the tests – know what it is they are testing and what that means for student understanding. Two, become an advocate for assessment that aligns with the school curriculum. Part of this advocacy involves campaigning to your peers and administrators. Third and finally, Popham says that a teacher should “arrange a more appropriate form of assessment-based evidence.” If I wish to assert that standardized tests are not an accurate form of measuring my quality as a teacher, I will need to be prepared with other forms of evidence of my students’ learning, understanding, and my effectiveness as a teacher.

Just like Sfard (2013), I find it hard to pinpoint exactly why mathematics is so pervasive in our society. As someone who plans to teach mathematics to high school students and possibly even become a mathematics teacher educator, this is an incredibly important tension that will likely not go away any time soon. Assessment is an invaluable tool for teachers to gauge learning and to plan for future learning. However, if we are to truly embrace reform mathematics, we must pay attention to the ways in which our practices are shaping beliefs. It matters little what we as teachers value and believe if our students do not come to experience the vision fully. It does them little good for us to stick our foot in the door and not go all the way through. We can change and improve what we as teachers do day to day and the ways in which we teach. But if at the end of it all, students are still coming to the conclusion that what matters is the right answer on the test, then reform has done little to impact the students and their beliefs.

And changing this will be hard – and undoubtedly not a job I can take on as a single teacher. No matter how much a teacher may believe in a reform, reform is change and change means it is going against what has become commonly known. When society at large has a different belief than the reform movement and when those who are in power did well in a system of traditional math, reform movements are not only slow, but they meet considerable barriers that, even when reform passes, is only met with resistance (Shepard, 2000).

Take Common Core for example. Even if Common Core is gone within the year, the policy of standards-based curriculum will certainly still be dominant when I become a teacher. But when Common Core was implemented, the various ways in which teachers were assessing their students did not match how society remembered their mathematics. The internet includes bountiful examples of parents who are calling for the math they had as kids. They have strong opinions about what math is and how it should be taught, and reform mathematics is foreign to them. It has become such a controversial subject, many states are changing their standards away from Common Core (albeit, sometimes just in name). Politicians and news agencies alike are asserting their opinions about what math is and how it should be taught.

I find it extremely ironic that this is the stance our society takes toward reform. The people calling for reform are education researchers and mathematicians alike. The common people acknowledge that they are experts and professionals in their field... That is, until they assert something counter to what we have come to know and, for some of us, have come to value. From both editorials online and comments from my peers, even people who say they had no interest in math in school, did not pursue math more than what was required, and considered themselves to be “bad” at math, were right there with reform protestors in saying that reform mathematics is not math. Strauss (2014) compiles an editorial along with comments by the public in order to give a broad view of what people are saying about Common Core. While not everyone who is against reform math are people who struggled with it, I am confused that people who did not like math in school would wish the same type of math for their children.

So what does this have to do with assessment? Well, it seems to be that students and teachers both understand at least one thing in common – doing well on standardized tests is vital to success. As a future teacher, I am not blind to the implications of my students’ test scores on my teacher evaluation. For students, standardized test scores have implications for GPA, college entrance, and placement in future mathematics classes. For teachers and schools, scores have implications for teacher evaluations, school evaluations, and school funding. With such high stakes, it is hard for students and teachers to believe that reform mathematics matters as much as getting right answers on the test. As a future teacher, it will be hard for me to not want to give them summative assessments that resemble what they will experience when they take their standardized tests.

And yet, this is what the reform is calling against. Changing the curriculum, we found, was not enough. And as Strauss (2014) points out, Common Core tried to push students and teachers away from tips and tricks so that the focus can be on *why* those tips and tricks work – a focus on the concept and not the procedure. And yet, since the tips and tricks help get good scores on standardized tests, why would students or teachers do something differently?

And herein lies the great tension. A vicious cycle is taking place through assessment and mathematics is left to suffer. Students come to learn what matters through the ways in which they are assessed and the ways they are taught. The high-stakes of testing affects what teachers believe to be what matters. The mathematics that “counts” is the ability to get right answers. These students go on to become members of society; they go on to become parents, teachers, and politicians. They continue to greatly influence how the next generation of students come to believe what “counts.” Those who succeeded in traditional mathematics classrooms are those who have one of the largest voices in deciding the future of mathematics (Spangler, 1992). When success on tests is linked to access to advanced classes, better careers, or higher education; when success on tests is linked to funding and job security – it is hard to imagine that anything other than success on the tests matter.

And I wonder if a big part of why many parents who disliked math in school advocate against reform math is because they realize that the assessments do not necessarily reflect the reform movement. Tips and tricks that can help get right answers are valued by students, teachers, and society – not reform math. And this tension of right answers versus understanding is a fundamental tension in assessment. What Erlwanger wrote in 1973 wrote about Benny and his ability to get right answers still reflects my experience with school mathematics and assessment. One would wonder why, after it was shown that right answers could be obtained assessments by completely unmathematical processes, we would have ever allowed assessments to continue to allow students to get right answers without understanding the mathematics. And yet, we are still writing about it today.

Perhaps people are not blind to the idea that math success is a gate-keeper for many jobs and careers in society. They see math success as a chance for social mobility – a manifestation of the American Dream. People are not blind to the idea that success can be achieved without understanding. And the more importance we put on success – the more high-stakes, the more consequences (grades, funding, college access, etc.), the more social value – the less we put on mathematical understanding as I have defined it in this paper (Shepard, 2000).

Reflecting on this, maybe it is not the over importance on success that is the issue. In fact, does not our ideal form of public education provide opportunities for success for all? No, I do not think the emphasis on success is the issue. I think the ways in which we have defined mathematical success via testing – correct answers found quickly and many times without the use of technology – is overshadowing and undermining the efforts of reform.

**Conclusion**

In conclusion, no one assessment can currently assess all students know or have learned about mathematics. They certainly do not assess mathematical understanding as I have defined it to be. It does not assess many of the things reform math stress as important. Regardless of this fact, we still attach very high stakes to the results of these assessments be it grades, access to advanced classes, entrance to college, teacher evaluations, school funding, or any other implication. Because of these high stakes, students are implicitly learning about what “counts” and what matters when it comes to mathematics. These beliefs have far reaching consequences including feeding into the vicious cycle of perpetuating math as a rule-based, fact-knowing subject. And while this vision of math may have once been useful, the times have changed.

Our society has technology that can fill procedural fluency gaps in ways that was not possible before. Our society now needs citizens who can communicate mathematically, solve non-routine problems, and come up with new and innovative ways to solve those problems. We need citizens who can learn from failure and not just know the math, but know *when* it is useful. Today’s problems are no longer routine – for technology can solve most routine problems. We need citizens who can tackle new, complex problems and be willing to persevere for a long time in solving it.

In “traditional” mathematics, problems are seen as a way for students to either a) practice what they have learned (e.g. a procedure), or b) an opportunity to show what they know (e.g. through recall). Reform mathematics – especially in inquiry-based learning – takes a new view of problems. Problems are seen as the context for which learning happens. This distinction is vital to the epistemologies they serve. It is a move from problems as a way to show what one knows to problems as a way to learn. And even if standardized assessments move to conceptually rich problem solving questions, the high-stakes attached to standardized assessments is predicated on the idea that it is evaluating 1) student achievement, and 2) education effectiveness (be it curricular effectiveness, school effectiveness, or teacher effectiveness). And as long as it is attempting to assess what has already been learned, the assessment is fundamentally different from the reform movement it is testing. The reform movement cares just as much about mathematical knowledge as a student’s ability to use that knowledge in various ways – more ways than just recall.

A major limitation of this paper is that it only examines the ways students come to their mathematical beliefs through assessment. Student beliefs are influenced by a host of factors and new research is always coming out on this topic. Another limitation of this paper is that it views assessment as a “problem” that just needs “fixing.” And while I provide a vague description of some steps assessment could take to align itself with reform, I could not provide a concrete description of what this assessment would look like. A third limitation of this paper is how firm my critique of assessment is through the medium of current reform movements. And as history has shown, it is likely that new theories of knowledge will emerge in my lifetime and new reform movements will take place.

The last critique of this Capstone that I would like to mention is that the reader might come away thinking that not just assessment, but the whole system of standardized achievement testing, is a barrier to implementing reform mathematics. This is predicated on the fact that as long as success on these tests have such high stakes for all involved – students, teachers, school, and community – then success on these tests will take priority. Any reform effort that moves away from preparing students for these tests will receive major pushback from the community (as seen with Common Core).

However, this is not the intention of this Capstone. In fact, a major point of this paper is that we perhaps could use the great influence this system has as a tool for reform instead of a barrier. For the influence this system has is undeniable. And the argument of this paper is less about how assessment is “bad” for reform mathematics and more about how re-conceptualizing assessment can perhaps create an environment more conducive for these reform movements.

And these are the things – the *use* of past knowledge and not just isolated past knowledge, the strategic use of technology, learning through failure, persevering through non-routine problems, reading and writing the world through math – that reform mathematics are calling for; what reform mathematics values. This is not what is assessed. What is assessed tells students what is important to know and be able to do. The vision of mathematics that the reform movement asserts and the vision of mathematics epistemology and literature are putting forth is not the same mathematics students come to know. Perhaps because it is not the same mathematics that “counts.”

References

Aiken, L. R.. (1976). Update on Attitudes and Other Affective Variables in Learning Mathematics. *Review of Educational Research*, *46*(2), 293–311. Retrieved from http://www.jstor.org.proxy.library.vanderbilt.edu/stable/1170042

Boaler, J., & Greeno, J. G. (2000). Identity, agency, and knowing in mathematics worlds. *Multiple perspectives on mathematics teaching and learning*, 171-200.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational researcher*, 18(1), 32-42.

Choi, J., & Hannafin, M. (1995). Situated Cognition and Learning Environments: Roles, Structures, and Implications for Design. *Educational Technology Research and Development*, 43(2), 53-69. Retrieved from http://www.jstor.org.proxy.library.vanderbilt.edu/stable/30220993

Collins, A., Greeno, J., Resnick, L. B., Berliner, B., & Calfee, R. (1992). Cognition and learning. *B. Berliner & R. Calfee, Handbook of Educational Psychology, New York: Simon & Shuster MacMillan*.

Common Core State Standards Initiative. (2010). Common core state standards for English language arts & literacy in history/social studies, science, and technical subjects. *Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers*.

Eisner, E. (1994).  The three curricula that all schools teach.  In *The Educational Imagination: On the Design and Evaluation of School Programs* (3rd ed., pp. 87-107). Upper Saddle River, NJ: Merrill Prentice Hall.

Erlwanger, S. H. (1973). Benny's conception of rules and answers in IPI mathematics. *Journal of Children's Mathematical Behavior*, *1*(2), 7-26.

Fuson, K. C., Kalchman, M., & Bransford, J. D. (2005). Mathematical understanding: An   introduction. *How students learn: History, mathematics, and science in the classroom*,   217-256.

Garfield, J. B. (1994). Beyond testing and grading: Using assessment to improve student   learning. *Journal of statistics education*, *2*(1), 1-11.

Gresalfi, M. S. (2009). Taking up opportunities to learn: Constructing dispositions in   mathematics classrooms. *The Journal of the Learning Sciences*, *18*(3), 327-369.

Gresalfi, M., & Barab, S. (2011). Learning for a reason: Supporting forms of engagement by designing tasks and orchestrating environments. Theory into practice, 50(4), 300-310.

Lockhart, P. (2009). A mathematician's lament. New York: Bellevue literary press.

Hubbard, R. (1997). Assessment and the process of learning statistics. *Journal of Statistics   Education*, *5*(1), 1-8.

Kapur, M. (2010). Productive failure in mathematical problem solving. *Instructional   Science*, *38*(6), 523-550.

McTighe, J., & O'Connor, K. (2009). Seven practices for effective learning. *Kaleidoscope: Contemporary and Classic Readings in Education*, *174*.

Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of   research. *Review of educational research*, *74*(3), 317-377.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author

Partnership for 21st Century Skills. (2009, December). Retrieved from P21:http://www.p21.org /storage/documents/P21\_Framework\_Definitions.pdf

Popham, W. J. (1999). Why standardized tests don't measure educational quality. *Educational   leadership*, *56*, 8-16.

Schoenfeld, A. H. (1988). When good teaching leads to bad results: The disasters of 'well- taught' mathematics courses. *Educational psychologist*,*23*(2), 145-166.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition,   and sense making in mathematics. *Handbook of research on mathematics teaching and   learning*, 334-370.

Schoenfeld, A. H. (2002). Making mathematics work for all children: Issues of standards,   testing, and equity. *Educational researcher*, *31*(1), 13-25.

Schoenfeld, A. H. (2006). What doesn’t work: The challenge and failure of the What Works   Clearinghouse to conduct meaningful reviews of studies of mathematics   curricula. *Educational Researcher*, *35*(2), 13-21.

Schoenfeld, A. H., & Kilpatrick, J. (2013). A US perspective on the implementation of inquiry- based learning in mathematics. *ZDM*, *45*(6), 901-909.

Sfard, A. (2013). *Why Mathematics? What Mathematics?* (pp. 130-142). Princeton University   Press, Princeton, USA.

Shepard, L. A. (2000). The role of assessment in a learning culture. *Educational researcher*, 4- 14.

Spangler, D. A. (1992). Assessing students' beliefs about mathematics. *The Mathematics Educator*, *3*(1).

Stake, R. E. (1995). The invalidity of standardized testing for measuring mathematics   achievement. In *Reform in school mathematics and authentic assessment* (Vol. 8, pp.   173-235). State University of New York Press Albany, NY, US.

Strauss, V. (2014, November 8). Why so many parents are freaking out about Common Core   math. Retrieved May 29, 2016, from https://www.washingtonpost.com/news/answer- sheet/wp/2014/11/08/why-so-many-parents-are-freaking-out-about-common-core-math/

Stein, M. K. (2009). *Implementing standards-based mathematics instruction: A casebook for   professional development* (2nd ed.). New York: Teachers College Press.

Stiggins, R. J. (2002). Assessment crisis: The absence of assessment for learning. *Phi Delta   Kappan*, *83*(10), 758-765.

Stiggins, R. (2005). From formative assessment to assessment for learning: A path to success in standards-based schools. *The Phi Delta Kappan*, 87(4), 324-328.

Onwuegbuzie, A. J., & Leech, N. L. (2003). Assessment in statistics courses: More than a tool   for evaluation. *Assessment & Evaluation in Higher Education*, *28*(2), 115-127.

Partnership for 21st Century Skills. (2009, December). Retrieved from P21: http://www.p21.org/storage/documents/P21\_Framework\_Definitions.pdf