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Consensus is the Answer Key: Liberating Science and Math Education

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by

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ABSTRACT

There is a pervasive hidden curriculum about science and math intelligence. It teaches students that being smart in these subjects means independently and effortlessly getting quick, correct answers. This hidden curriculum is inaccurate, disempowering, and unjust. A classroom dynamic called "Consensus is the Answer Key" is an effective way to rewrite this hidden curriculum. By solving complex problems and using group discussion that calls for logic and communication skills, students effectively learn science and math content, as well as gaining the skills and confidence to be successful in these subjects.

Upon learning that I teach math and science, adults often tell me, "I could never do math or science – you must be really smart!" This short response reveals that people perceive ability in these subjects as a given quantity that one either has or has not, and that they link math and science ability to overall intelligence. For numerous reasons on an individual and societal level, it is important to replace this thinking with the liberating – and accurate – understanding that everyone has math and science abilities, and that effort increases them. An effective method for replacing this common misperception about math and science intelligence, and for ensuring learning in these subjects, is a classroom dynamic called "Consensus is the Answer Key."

Changing the Hidden Curriculum about Math and Science Intelligence

Students learn much more than facts and skills in school. They also learn about social and cultural norms, often in subtle ways. This type of information that students learn, without being explicitly taught, comprises the "hidden curriculum" of schools. Hidden curriculum is "the norms and values that are implicitly, but effectively, taught in schools and that are not usually talked about in teachers' statement of end or goals" (Apple, 1998, p. 54). In math and science, a pervasive part of the hidden curriculum teaches what it "looks like" to be smart in math and science: getting quick, correct answers, with little effort (Bransford & Donovan, 2005). Further, students learn that a chosen few receive this intelligence at birth, and the rest are forever deficient. This pervasive hidden curriculum about math/science intelligence is inaccurate, disempowering, and unjust.

This perception about math and science intelligence is inaccurate because it misrepresents what the very "smartest" of us in math and science – mathematicians and scientists – actually do. Scientists and mathematicians work collaboratively, deal with problems that do not yet have "right" answers, and often spend years on a single problem (Bransford & Donovan, 2005; Kuhn, 1962). Key attributes of the culture of science are "hypothesis generation, modeling, tool use, and collaboration," not quick fact-recall (Bransford & Donovan, 2005, p. 398). In fact, studies of expertise have found that experts sometimes take longer to solve problems than novices (Bransford, Brown, & Cooking, 1999). In the area of physics, college students usually started answering problems more quickly than professional physicists. The latter took longer to understand the problem, and often stopped to draw a qualitative diagram before attempting to apply formulas (Bransford et al., 1999). The National Standards for both Math and Science Education emphasize community and collaboration as attributes of their expert communities, as well as traits to develop in students (National Research Council [NRC], 1996; National Council of Teachers of Mathematics [NCTM], 1999). In sum, intelligence in math and science is not about getting quick, effortless answers, but about thinking well about problems and taking the time to solve them effectively, using whatever tools and resources are appropriate to the situation.

In addition to being inaccurate, the hidden curriculum's message of math and science intelligence being innate and fixed is disempowering to students. It adversely affects students regardless of whether they're labeled as smart or not. The students who are labeled as bad at these subjects stop trying because trying seems fruitless: if you either have the smarts or do not, effort is irrelevant. Interestingly, this label also cripples students who are labeled as "smart" because true smarts are supposed to be effortless. Rather than working harder when they encounter challenging material, these students employ ineffective defense mechanisms that inhibit rather than enhance learning (Dweck, 2002). There are also social implications of this inflexible labeling in math and science as smart kids become "nerds" and intelligence becomes social suicide for popular kids, especially girls (Pipher, 1995).

The implications of this inaccurate, disempowering, hidden curriculum are disturbing on both an individual and a societal level. Because math and science ability is often equated with overall "smarts," it can determine one's entire sense of intelligence. Students who lack confidence or effort in these fields are unlikely to succeed in them, yet math and science abilities are becoming more critical to navigating our increasingly technological world and to holding positions in powerful, influential fields (American Association for the Advancement of Science (AAAS), 1993). In addition, math and science often act as "gatekeeper" subjects, which students must pass to progress in higher education, and those from disadvantaged backgrounds are less likely to do so (Moses & Cobb, 2001). Because of the disproportionately negative impact of ineffective math and science programs on poor and minority communities, civil rights activist, Robert Moses, sees math education as today's biggest civil rights issue, and numerous programs and schools have sprouted up to address this.[1]

It is crucial and difficult to change this hidden curriculum about math and science intelligence. It is crucial because we do not want students learning inaccurate, disempowering information in our classrooms, especially when this leads to unjust societal outcomes. It is difficult because this view of math/science intelligence is deeply embedded in our culture and habitual daily practices. Because it would make no sense to replace this hidden curriculum with a new one that is also inaccurate, changing the hidden curriculum is not simply a matter of making students feel better about themselves. False confidence in one's abilities is no more liberating than lack of confidence. Therefore, addressing the hidden curriculum requires students not only to ***feel*** successful, but also to ***be*** successful. Achieving these goals can be a complicated and multifaceted enterprise involving curriculum, instruction, assessment, and school culture. Obviously, approaching this in all aspects of the school has the best chance of success, but it is not necessary to redesign an entire school in order to have a profound impact on students' perception of math and science intelligence. Because it directly contradicts inaccurate notions of math and science intelligence and simultaneously uses the best research–based pedagogical practices, "Consensus is the Answer Key" makes a powerful difference in this endeavor.

Consensus is the Answer Key, Defined

"Consensus is the Answer Key" is a classroom dynamic whereby students get feedback on solutions from class discussion and agreement, not from answers in the back of a book or the teacher.[2] "Expert" sources of verification are removed, and students instead use their own logic, creativity, communication, and collaboration skills to solve problems. There are multiple ways throughout the process whereby students check the validity of their answers, and I design appropriate lessons and future problems based on the student understanding and misperceptions that are revealed through the process. The structure is an

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[1] In addition to Moses' Algebra Project, there is also the Young People's Project which was an outgrowth of the Algebra Project, as well as many schools across the country such as the Young Achievers Science and Mathematics Pilot School in Boston

[2] This term was first coined by Ted Dreith, and developed by teachers, including myself, through years of classroom practice.

inextricable part of our classroom culture and routines, whether we are discussing a set of homework problems or a weeklong problem-solving challenge. It is not a technique that we occasionally insert into class. In short, the steps of the process are:

1. Students have problems to solve.
2. Students work on the problems individually or collectively.
3. Students present their solutions to the class or group.
4. Using logic, questioning, and explanation, students come to consensus on the answer.
5. Based on the knowledge, skills, and misperceptions revealed through this process, the teacher chooses the next appropriate lesson or problem to solve

This approach changes the definition of math and science intelligence. My students are engaged daily with the rich, complex processes that teach the value of depth and thoughtful collaboration rather than speed and individuality. In addition, the hidden curriculum becomes explicit by teaching skills such as presentation and collaboration, and through discussing the values surrounding these practices.

<u>The Practice of "Consensus is the Answer Key"</u>

<u>Step One: Students Have Problems to Solve</u>

The process begins with a well-chosen problem with desired content and skill outcomes. To help students practice discrete skills, such as how to balance a chemical equation, the problem(s) could be a set of traditional problems on a worksheet. To help students learn skills like logic, problem solving, and working with real-world uncertainty, the problems should be complex and open-ended. I call the latter "Problem-Solving Challenges" or "PSCs." Examples of PSCs are:

- Create a universal method to determine the terminal velocity of a person falling with a parachute.
- Design a fair method for choosing the number of Congressional members each state should get in the House of Representatives

Choosing complex, open-ended problems is key to student success, especially for students who have previously struggled in science and math. Rather than acting on the assumption that struggling students need easier problems that are broken down into steps, I believe the opposite. We should give students challenging problems, ones that they initially perceive themselves as unable to solve, and then give them the time and support to solve them. This is a superior strategy because students know that they are solving real problems, rather than dumbed-down versions, and because it is more likely to lead to success. Rich, complex problems can be solved in multiple ways, but if we teach them in broken-down steps, we can only choose one way to solve the problem. Time and again, I have seen students who were considered "bad" in math and science come up with creative solutions that differed from all of their classmates'. Rather than forcing these creative minds into a problem-solving strategy chosen by a teacher or textbook, this process allows students to develop and refine their own style and then offer it as a way to enrich the class.

Well-chosen PSCs can both develop problem-solving skills and introduce students to new material that they have yet to formally learn. For example, before learning about projectile motion, my students worked on solving the problem, "What is the horizontal distance that an unrestrained 75kg man would travel from a roller coaster seat 1m above a horizontal track, if the car abruptly stopped after traveling at 25m/s?" (This problem was developed with students, who always seem to love problems involving crashes!) By investigating this problem in groups with conversation and feedback, students gained skills in developing models, collaboration, communication, and problem solving. In addition, many groups made qualitative discoveries about physics principles, such as the fact that a projectile object travels a longer horizontal distance with a higher initial velocity. In addition, this problem created an investment and "need-to-know" amongst students that led to higher motivation when I taught the concepts and formulas for projectile motion. When providing students with such information through direct instruction, they were better able to comprehend it because they had a previous experience to which it could be linked, a key component of learning as explained by the constructivist model. (Bransford et al., 1999; Brooks & Brooks, 1999).

A final aspect of a well-chosen problem is that it is interesting to students. Key ways to engage this interest include:

- choosing problems that clearly relate to students' lives ("You send a cell phone picture of yourself to your boyfriend, and he sends it to his three closest friends.

They then sent it to their three best friends. This happens every fifteen minutes for two hours. How many people have seen it by the end of the two hours?")

- choosing problems that have real-world applications ("Build a model power plant that converts a fossil fuel into electricity.")
- asking students to help construct problems (such as the problem of the man flying off the roller coaster).

Starting with problems, especially real-world problems, helps students "conditionalize" knowledge, meaning that they learn the contexts in which information is applicable (Bransford et al., 1999). Without this, knowledge remains "inert," and people do not access it when necessary (Whitehead 1929).

It works best to first teach the process of Consensus is the Answer Key using a complex problem. Complex problems take longer to solve so there is more time for me to provide feedback to students throughout the process. In addition, problems that are too challenging to solve quickly require students to devote more time to discussing the process rather than simply comparing answers. Assigning big, complex problems also prevents a class dynamic in which students place one of the "smart" students in the expert role that I have vacated. If problems are too simple, a single student can often quickly and confidently solve them, and the rest of the class will use that individual as their answer key rather than engaging in rich dialogue. Big, challenging problems engage all students in the kind of work that develops intelligence, logic, creativity, and communication skills. After the norms are established, students tend to continue these habits of good dialogue and checking each other's work for future problems, even repetitive, quick problems for practicing skills.

Step Two: Students work on the problem(s) individually or collectively

Students work on the problem by themselves and in small groups. I often assign problems initially as homework so that all students, regardless of processing speed, have time to grapple with the problems before we begin discussion. This tends to be especially beneficial for working on sets of practice problems because this type of repetitive practice can accentuate differences in work speed. Homework time provides flexible work time so that all students come to class having made progress on the problems.

As students work, I provide feedback, questions, and coaching oriented towards developing students' problem-solving and collaboration skills. Within this model, students ultimately get feedback from sources other than me so that they develop lifelong skills that aren't dependent on a teacher. Other sources include fellow students, their own use of logic and proof, and measuring their work against clear goals or expectations. Getting to the point where students look to these sources for feedback or affirmation requires scaffolding (Shulman, 1990).

There are a number of specific tips for providing educative feedback to students. The feedback that teachers give to students is one of the primary vehicles for helping to re-write the hidden curriculum's stance that math and science intelligence is a fixed quantity, regardless of effort or experience. I want students to know their intelligence and abilities are malleable entities over which they can exercise agency and control.[3] One key way to send this message is to give feedback about observable actions because actions, unlike attributes, can be changed. Rather than telling a student, "You're great at science," I say, "You did a great job of stating the problem and using logical strategies to solve it." To help students internalize their own evaluation skills, I provide observations of student actions and then ask students to interpret their value or meaning: "I noticed that you started by breaking the circle in half. Why did you choose to do that?" The last step of this scaffolded process is to ask students to both make the observations and the interpretations themselves: "Tell me what you've done so far." Then "How is that working?". (See Table One for additional examples.) Along with providing students with the tools to evaluate work on their own, this type of feedback also avoids a common drawback of general praise and criticism: that they act like other rewards and punishments to decrease students' intrinsic motivation and orient them instead to extrinsic motivation provided by a teacher (Kohn 1993). Thus, this feedback both enforces the attitudes and the skills needed for independent learning.

Along with giving feedback, I ask questions to develop students' logic and communication skills. The most common question I ask is how they got their answers, ***both*** correct and incorrect ones. It is problematic when teachers only question wrong answers because students quickly understand that a question means they made a mistake. I also want

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[3] See Dweck (2002) for a discussion of how teacher feedback affects students' view of intelligence as fixed or malleable, and for the resulting changes in confidence and behavior.

Table 1: Giving Empowering Feedback to Students

Do	Don't
Comment on Specific Observable Actions ◆ "You did a great job of trying a number of different ways to solve that problem." ◆ "When you laughed as Lisa was up at the board, it made her feel badly." *Make Observations and Ask for Student Interpretation* ◆ "I noticed that you started by breaking the circle in half. Why did you choose to do that?" ◆ "I noticed that you laughed when Lisa was up at the board. How do you think that affected Lisa and/or the class?" *Ask Students to Make Both Observations and Interpretations* ◆ "Tell me what you've done so far." Then "How is that working?" ◆ "Tell me about your homework over the last week." Then "What's going on?"	*Comment on Students' Abilities or Attributes* ◆ "You're so smart!" ◆ "You're always so mean." *Give Simplistic Answers that Stop Student Thinking* ◆ Student: "Is this right?" Teacher: "No" ◆ Student: "Is this good?" Teacher: "Yes" ◆ Student: "Am I on the right track?" Teacher: "Looks like it!"

my students to learn that being questioned by someone in authority does not mean they are wrong or need to change their position.[4] In addition, it is vital for students to explain how they got correct answers because this helps them to understand the material in more depth, remember it better, and develop clear communication skills.

Along with helping students develop problem-solving and communication skills, I also use work time to help students develop collaboration skills. As a foundation for developing collaboration skills, I begin each course by establishing a safe and respectful classroom culture. This process is different depending on the overall school culture and the make-up of any individual class, but it always includes establishing clear expectations, often in conjunction with students, and uncompromisingly sticking to them. Once the safe and

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[4] See Illich, 1971, for a discussion of the problems with the authority that teachers exert over students. Although I disagree with his conclusions about disestablishing school, I agree with his argument about the issues with the imbalance of power in the teacher-student relationship.

respectful classroom norms are established, I help students learn how to work collaboratively, because they often come to me only able to work individually or copy others' answers. To do this, I often simply engage another student in a conversation with a first student. (Ex: "Beccy, can you explain your steps to Leroy?" Then, "Leroy, do these make sense to you?") I also remove myself, directing students to ask questions of each other. (Ex: Student: "Am I doing this right?" Teacher: "Explain what you did to Scarlet and see what she thinks.") It does not take long for students to learn to go to their classmates before me when they have questions. Because they are motivated to solve the problem and are adhering to our guidelines of a respectful, safe environment, they quickly learn effective collaboration skills. This is beneficial to students because collaboration skills are important for life and future work (The Partnership for 21st Century Skills [P21], 2009; NRC, 1996; NCTM, 1999) In addition, this part of the process can be especially beneficial to students who struggle with social skills. Often, students who are considered smart in math and science are also considered nerdy or awkward. When they learn to collaborate effectively with others, they can overcome social hurdles and establish skills and connections.

The independent work time and open-endedness of PSCs activates student engagement, making them the central players in their education rather than passive receptacles of information. Such student-centeredness is vital for both moral and pedagogical reasons. Morally, Paulo Freire effectively argues against the "banking model" of education in which teachers deposit information in students during lectures and withdraw it during tests. Instead, students should move from being "Objects" to "Subjects" in their education, raising their consciousness as they engage in dialogue about problems that are relevant to their lives (Freire, 2005). Pedagogically, student-centeredness allows me to closely observe student work and conversations to assess understanding. Such ongoing assessment of student learning is a key contributor to successful mastery of material (Shepard, 2000; Black & Wiliam, 1998) In addition, student-centeredness addresses the fact that "simply telling students what scientists have discovered … is not sufficient to support change in their existing preconceptions about important scientific phenomena" (Bransford & Donovan, 2005, p. 398). "Students bring extremely robust forms of sensorimotor and symbolic knowing, which have already evolved to a high degree even before a child enters school." (Gardner, 1993, p. 149) Teachers need to access and engage students' incoming perceptions to effectively teach science and math concepts. Failure to do so results in student misperceptions persisting through years of schooling. This was dramatically demonstrated by Harvard graduates, many with substantial science coursework, who were almost universally unable to accurately explain why we have seasons (Schneps & Sadler, 1987) and has been documented in numerous similar studies (Gardner, 1993). When students are the central focus in the classroom, I can best avoid sending inaccurate messages, both about the amount of respect they deserve, and about the science and math content.

Step Three: Students Present Their Solutions to the Class

Whole-class presentations provide a particularly rich opportunity for students to master communication and collaboration skills. I preface such discussions with explicit instruction on how to present and discuss solutions. At some schools, these instructions include a step-by-step list of what the presenter should do, clear descriptions of the presenter's and participants' roles, and guidelines of how students should treat each other. I've found posting such information to be very helpful (see Figure 1). At other schools, I've kept things simpler by stressing the key goal of each person: The presenter's goal is to "be clear", and the participants' goals are to first "understand" and then "offer questions and feedback" towards a consensus answer. I repeatedly remind students that they cannot make suggestions or share criticism until they understand what the presenter is saying. Once they understand, then the participants' role is to critique and suggest until the class comes to consensus.

After explicitly teaching these guidelines, my role is to safeguard the process. This student-centered, learning-centered classroom requires intentional work on the teacher's part and is not a laissez-faire approach. Freedom is often confused with non-interference (Kandel 1998), but helping students to internalize the skills and confidence to effectively problem-solve is counter-cultural and requires deliberate action on my part. For the beginning months of a school year (and longer if necessary), I sound like a broken record before each student presentation, reiterating guidelines, as well as presenter and participant roles ***each time*** someone presents. In addition, I correct students if they stray from our guidelines. As in the small-group collaboration, the essential foundation for this process is an uncompromisingly safe classroom environment. Rigorous, creative, and difficult dialogue requires that students

Facilitation Script for Presenting a Problem

1. Clearly explain every step that you took. Point to the different parts on the board
2. Ask if anyone has any questions about what you explained.
3. Ask if anyone disagrees.
    a. IF NO ONE REALLY ANSWERS, THEN … call on each student in the class to say her/his answer
4. If anyone has a different answer, ask them to come to the board and explain how they got their answer
5. Then, ask yourself and the class which answer is right and WHY
6. Keep discussing until everyone agrees
7. When everyone agrees, clearly re-state the answer and/or draw a box around it on the board.

Figure 1: Presentation Script

feel safe to take risks, say incorrect things, and make mistakes. Thus, I never let an infraction pass, even "joking" put-downs.

I have also found it helpful to begin student presentations before any student has had a chance to come to a final answer. This erases the dynamic whereby some students feel like they're "in-the-know" and some students feel out of it. In addition, it demands a level of rigor in the discussion that can be glossed over if students are focused on the answer instead of the process.

Sometimes I give students more independent and small group work time after initial presentations, especially early in the year when they are learning the process. Seeing other students' work towards a solution will often trigger expanded creativity and insight in their own work. Sometimes we do presentations later in the process and go directly towards consensus. For more discrete problems like solving an equation, we go directly to consensus building.

Step Four: Using Logic, Questioning, and Explanation, Students Come to Consensus on the Correct Answer

In this step, students come to a final answer that they all agree upon and understand. Now that the class has a proposed solution in front of them, they ask questions, offer alternatives, and give explanations. Their goal is to deeply understand a correct solution that is clear and refined. It is the responsibility of each student to ask questions and offer suggestions until s/he fully agrees with and understands the class' solution. Ideally, multiple students will make their way to the board in order to revise or clarify the solution written up there. I stress the value of making mistakes and publicly thank students who go to the board with incomplete solutions, emphasizing that a lot of our richest learning comes from knowing why a mistake is not correct.

Many classrooms that emphasize student voice encounter the pitfall of ending discussion once students have expressed their initial ideas and thoughts. Then, students have not learned anything about determining the quality of work and thought, and often lack an advanced, refined understanding of the content material. When students share ideas, it is important for them to get feedback on those ideas and abandon or refine those that don't hold up to scrutiny. Some teachers feel uncomfortable with students' thoughts being criticized, but critical feedback is one of the greatest gifts that we give our students because it sends them the message that we know they can grow. Therefore, this discussion stage is vital for refining students' logic and communication skills, along with their content knowledge.

There are key ways that I facilitate the discussion and clear guidelines that we use. It is important that the discussion be about the problem and its solution rather than about individual students. We use the motto, "Only attack the idea. Never attack the person." In addition, I de-personalize suggested solutions when we are working towards consensus. If two students have written different proposed solutions on the board, I will call them solution A and B rather than "Juan's solution." This makes it easier for students to focus on ideas rather than people, and it makes sense because numerous students will hopefully refine Juan's initial solution so it becomes a group solution. I am also very rigorous about the language used during discussion. One example is that students often begin the school year using language like, "You're wrong." Instead, I have them say, "I disagree." Although this may sound like a minor point, I've found it to be very important. It keeps students from becoming defensive or attacking and creates a more collegial, open atmosphere. In addition, it's more rigorous language. I almost always have an opportunity to make this point early on when a student says "you're wrong" and later realizes that she herself was wrong: it makes more sense to say, "I disagree," or "I have a question," until the right answer is established.

As students become proficient at "Consensus is the Answer Key," I take deliberate steps to "disappear" during whole-class discussions. I move to the back of the room, and students are in the front of the room, presenting their work. They feel more and more empowered to go up to the board to explain their ideas without asking my permission. From the back of the room, I am able to observe all of the students in the class, once again giving me a great vantage point for assessing understanding. This physical position also pushes students to direct their presentation to their classmates rather than the far-away teacher. If they need further encouragement to do this, I will deliberately stop making eye contact with the presenter, looking down at my paper instead. Inevitably, they begin to speak to each other rather than to me.

Step Five: Based on the knowledge, skills, and misperceptions revealed through this process, the teacher chooses the next appropriate lesson or problem to solve

Once students come to a consensus answer, we've come to the end (and thus, beginning) of a cycle. As the teacher, I now need to evaluate what the class understands, determine the next opportunity for learning, and then design instruction or pose a new problem to move the class forward. Fellow educators often ask me what to do if students come to the wrong answer through this process. Before answering that question, it is important to note that students routinely leave traditional math and science classes with persistent misconceptions, even when they have been told correct information (Schneps & Sadler, 1987; Gardner, 1993; Bransford & Donovan, 2005). These misperceptions are often left unexposed because of "correct answer compromises," which Gardner describes as

> "an uneasy kind of détente. Teachers require students to answer preset kinds of problems, to master lists of terms, and to memorize and then feed back definitions upon request. They do not ask students to try to reconcile their earlier, partial forms of understanding with the notations and concepts of school; instead, they deal only with the latter

> forms of knowing, hoping that students can later develop the reconciliations on their own. Nor do teachers pose challenging problems that will force their students to stretch in new ways and that will risk failures that might make both students and teacher look bad." (1993, p.150)

"Consensus is the Answer Key" is the opposite of a "correct answer compromise," which means it is riskier and messier, but it is high quality, effective education. Student misperceptions rise to the surface where I can address them.

As far as classes coming to wrong answers with "Consensus is the Answer Key," it rarely happens with well-chosen problems and an engaged, functioning class. However, there are times when an entire class will refuse to rigorously examine a solution or will all "agree" with someone's answer, even an incorrect one, without fully understanding. It is also entirely possible to assign an initial problem for which students do not have the content knowledge necessary for a correct solution. It is ***good*** to hit the point at which students come to an incorrect consensus or can't reach consensus despite their best efforts. This is one of the richest educational opportunities because a persistent misconception, a need for knowledge, or a sloppy habit of mind has now been exposed. I may give students content knowledge they now need, assign a new problem, or directly confront the students' lack of engagement and have them re-do the original problem. For example, during a unit that I was co-teaching about positive and negative numbers, students were asked to find the difference between a bank balance of $100 and an earlier balance of being $20 in debt. They knew to use subtraction to find the difference between two numbers, but did not recognize that debt was a negative number. Thus, the entire class was insistent that the answer was $80 ($100 - $20). So, we assigned a homework problem requiring the students to draw out the problem on a number line. We had thus not told the students they were wrong, had not given them an easy out by explaining the right way to solve the problem, and had created a problem that illustrated the concept in a way that students would remember. Although this process took longer than simply showing the students how to solve the problem, it was a far richer learning experience. The students learned the content knowledge in a way that they understood and are unlikely to forget, and they simultaneously learned problem-solving skills. Students regularly referred back to that problem throughout the rest of the course, joking about how angry they were with us because we wouldn't let the problem end. In the same way that I question individual students on both correct and incorrect answers, it's good to routinely assign problems that test the validity of a class' consensus answer, both correct and incorrect ones.

Challenges and Benefits

Implementing "Consensus is the Answer Key" is quite challenging because it is so counter-cultural. Students, administrators, and parents are all likely to be confused by the process and need lots of explanation. It is very important to have framing conversations before the course about the process. When I have let administrators and parents know in advance that they should expect student frustration and complaint, they have overwhelmingly worked well with me to support students through that obstacle when it arises, rather than being displeased with the teaching method. Having such allies is helpful during the predictable time at the start of implementing this practice in which students are upset that I have pulled away as their "crutch" and will try every tool they possess to get me to leak an answer. Consensus is the Answer Key is unfamiliar territory to students, and they feel nervous until they have gotten to the gratifying, and often exhilarating, endpoint of seeing consensus happen. Another cultural challenge is that we teachers have been steeped in the dominant schooling culture, and are likely to unconsciously retain habits that undermine the process. Training pre-service teachers is one way to help address this, and it is vital that such training be coupled with ongoing observation and feedback amongst colleagues.

One more challenge is time. It takes longer for students to learn facts and information through Consensus is the Answer Key than through direct instruction. Teachers are often charged with enormous lists of topics that we are supposed to teach students in a short period of time. Consensus is the Answer Key is not an efficient way to deliver large quantities of facts, and if that is the goal, it is not the best classroom structure. If however, the goals include logic, problem solving, communication, and collaboration skills, then Consensus is the Answer Key is an effective way to ensure that these skills are truly learned. Such skills could be efficiently told to students such that students could explain them on a test, but being able to actually use them takes practice, experience, and refinement. These processes that can't be rushed and still retain their effectiveness. In addition, students learn the facts that accompany these processes with depth, the ability to use the information, and a much better chance of remembering it.

Time becomes a more pressing challenge in the era of No Child Left Behind and standardized testing. These tests call for many "correct answer compromises." In public schools, constrained by testing pressures, how to spend valuable classroom time is always a balancing act, and teachers will sometimes need to strike "correct answer compromises" in order to cover enough content to get their students to pass certain standardized tests. Despite the need to occasionally work on covering broad amounts of content material, Consensus is the Answer Key is still useful in these classrooms because it teaches valuable skills, and it even teaches skills that are useful for test success. Teachers can choose test questions and use Consensus is the Answer Key to help students explore the questions, explain correct answers to each other, and thus become better test-takers.

Despite its challenges, the benefits of using "Consensus is the Answer Key" are innumerable. Time and again, my co-teachers and I have watched those precious "ah-hah" moments in which students not only come to understand a concept, but come to understand that they are capable of solving math and science problems. Over and over, students have told us, "I never thought I could do math, and then I solved this problem. I realized that you didn't teach me how to do it; I figured it out on my own." This transformation often fuels a transformation in their confidence across academic disciplines since math and science were previously seen as the impenetrable subjects. Students see that if they can be successful in these subjects, they can be successful anywhere.

The benefits are also innumerable to me personally as a teacher. I will never be tired of seeing the same thing year after year. Instead, I am continually amazed at the new and creative ways students solve problems and inspired by students' breakthroughs. Such inspirational experiences in the classroom are vital for maintaining one's commitment to the incredibly challenging, and often discouraging profession of teaching (Palmer, 1998). Because of the positive benefits of Consensus is the Answer Key to teachers, its use can keep dynamic, reflective, intellectual teachers in the profession. As I am inspired by students' accomplishments, I am better able to teach them because of my unequivocal belief in them. Methods are meaningless unless based upon a teacher's faith in her students' innate intelligence, ability to learn, and ability to make positive contributions to the world (Macedo 2005).

In the end, "Consensus is the Answer Key" has provided the environment for numerous students to succeed in the complex and often intimidating world of math and science. Rather than feeling left-out or constrained by what the hidden curriculum previously taught them about math and science intelligence, these students now have a more accurate and empowering view of such intelligence and know themselves to possess it. Not only does this transform their view of themselves in math and science, but it also changes how they perceive themselves as students, intellectuals, and capable individuals. Such transformation is the essence of education.

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