Standards-based Teaching in Math and Science: Why It Is the Wrong Approach and What Schools Should Do About It

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Abstract

In this article the author defines the phrase "Standards-based teaching" and then discusses the problems inherent in this approach. The author also offers multiple suggestions regarding what schools should do to address these problems when teaching math and science.

Introduction

The No Child Left Behind Act (NCLB) of 2001 required that all states develop standards in reading, math, and science and that they also develop proficiency tests to measure student achievement in each of those three disciplines. All public schools were required to administer those tests at least three times in grades 3-12, in order to determine whether their students were making adequate yearly progress (AYP). In 2015, the Every Student Succeeds Act was signed into law. Scheduled to go into effect in 2017, ESSA decreases the federal government's role in education and gives states more control over their policies (Klein, Alyson, 2016); however, ESSA continues the NCLB requirement that states maintain academic standards in reading or language arts, math, and science and that they be tested in reading or language arts and math in grades 3-8 and once in high school and in science once in grades 3-5, 6-9, and 10-12 (Council of Chief School Officers, 2016)

Many school districts have responded to their state requirements by utilizing something we might refer to as "standards-based teaching." Standards-based teaching involves one or more of the following actions: (a) narrowing the curriculum, (b) adopting the standards as the primary source of curriculum, (c) using traditional approaches to teaching, and (d) implementing test-coaching programs. This article will focus on why this is the wrong approach for teaching math and science and what schools should be doing instead.

Why Standards-based Teaching is the Wrong Approach

Administrators and teachers often rationalize that, since schools are being judged based on the proficiency test scores of their students, it is incumbent upon them to employ a standards-based teaching approach. Following are some reasons that standards-based teaching is the wrong approach for schools to take.

Standards and the Narrow Curriculum

One of the reasons it is problematic to use standards-based teaching is that this approach narrows the curriculum as schools adjust the amount of time devoted to various subjects. In 2007 McMurrer found that five years into NCLB 62% of schools in the United States had substantially increased the time spent on language arts and math instruction, with a corresponding decrease in subjects such as science, social studies, art, music, and physical education.

In contrast to the United States, the highest performing nations around the world approach curriculum from a much more global perspective. Munson (2011) reported on the results of a study conducted by a nonprofit research organization known as *Common Core.* In this study *Common Core* researchers investigated curricular differences between schools in the United States and schools in nine other nations that scored higher than the U.S. in reading, math, and science on the 2009 Programme for International Student Assessment.

The researchers found that schools in the high-performing countries emphasize the arts, literature, history, geography, civics, reading, and math, while schools in the United States focus most of their attention on preparing students to take skills tests in reading and math. In our effort to increase reading and math skills, we have devalued content knowledge, even though cognitive psychologists such as Willingham (2009) have long maintained that background information is essential to acquiring skills. This would explain why students in many other countries continue to out-perform students in the United States in reading, math, and science. We have narrowed the curriculum to such an extent that it appears that our instruction has lost much of its effectiveness.

Standards as the Primary Source of Curriculum

Another reason it is problematic to use standards-based teaching is that the standards do not provide a coherent curriculum. One area of concern has to do with the fact that the standards do not include a complete scope, due to the many gaps that are found within them. Let's start with math and a study of division at the fourth grade level. The Common Core State Standards include one standard (CCSS.Math.Content.4NBT.B.6) with two statements for this topic. Conversely, a popular elementary math textbook program includes 17 lessons for the topic of division. Clearly, there are gaps in the standards regarding the topics that teachers should address when teaching division to fourth grade students.

We find a similar situation in science. Consider a study of magnetism and electricity at the fourth grade level. The Pennsylvania Department of Education (PDE) Standards Aligned System (SAS) for Science, Technology, and Engineering lists one standard (Standard 3.2.4.B4) with three statements for this topic. In contrast, a popular elementary science textbook program includes 17 lessons on magnetism and electricity. There are obvious gaps in the standards when it comes to the topics teachers should address when teaching magnetism and electricity to fourth grade students.

In addition to concerns about the scope of the math and science standards, there are also concerns about the sequence of the standards. Since there are so many gaps in the state standards for math and science, it is impossible to determine what sequence should be followed when addressing various topics. On the other hand, the popular textbook programs provide a complete set of topics and a logical sequence for when various topics should be addressed. For example, in math a textbook lesson on estimating quotients precedes a textbook lesson on dividing with remainders. Similarly, in science a textbook lesson on closed versus open circuits precedes a textbook lesson on series versus parallel circuits.

It is obvious that the standards do not provide a coherent curriculum, due to the fact that they do not include a complete set or a logical sequence of topics that should be addressed. As a result, teachers who use the standards as the primary source of curriculum in math and science are likely to skip over many important topics. The problems caused by this situation are not likely to be overestimated. When students lack background knowledge and skills in a particular area, it is impossible for them to move on.

Perhaps no one has made this point more clearly than a noted cognitive psychologist by the name of Gagne. Writing in 1977, Gagne stated, "The function of instructing derives in a specific sense from a description of the required conditions of learning. Instructing means arranging the conditions of learning that are external to the learner. These conditions need to be constructed in a stage-by-stage fashion, taking due account of each stage of the just previously acquired capabilities of the learner, the requirements for retention of these capabilities, and the stimulus situation needed for the next stage of learning" (p 23-24).

In order to arrange the conditions of learning in a "stage-by-stage fashion," it is imperative that schools follow a coherent curriculum, one that provides a complete scope and a logical sequence of topics. When this occurs students are more likely to have the prerequisite knowledge and skills required to move to the next level. When this does not occur, students are not able to advance, they become anxious about their lack of understanding, and teachers become frustrated by the lack of growth they observe in their students.

Standards and Traditional Approaches to Teaching

Unfortunately, many schools have decided that the best way to prepare their students for the proficiency tests is to use traditional approaches to teaching such as lecture, worksheets, and drill and practice. In 2007 Au synthesized the results of 49 recent studies and found that in over 80 percent of the studies there was an increase in teacher-centered instruction as a result of NCLB. With traditional approaches, the teacher's primary role is to present information, the student's major role is to take the information in, and the main focus is on memorization.

The problem with traditional approaches is that they do not match the essential link that many theorists have established between engagement and learning. For example, consider the work of well-known Swiss epistemologist, Jean Piaget. One of the primary tenets of Piaget's theory of cognitive development is that children are active learners and that intelligence develops as they construct their own understanding. Piaget identified three specific types of experiences which he described physical, logical-mathematical, and social that he viewed as essential to learning

Consider also the work of a popular Russian psychologist, Lev Vygotsky. According to Vygotsky, children develop their intelligence through interactions with the social environment.He viewed children as active participants who construct knowledge and skills as they become involved with people and various artifacts such as toys. For both Piaget and Vygotsky, learning is an active process. Though well-intentioned, many schools have succumbed to the pressures associated with NCLB by resorting to the use of teaching strategies that involve a more passive approach.

Standards-based Teaching and Test-Coaching Programs

Many schools have developed test-coaching programs to help their students prepare for the proficiency tests. The problem here is that test-coaching programs decrease the available instructional time, and as a result, may actually result in lower test scores. The reason for this is that it takes time for the human brain to process information and develop new neural connections (referred to as axions and dendrites by neuroscientists).

Every hour devoted to test-coaching means one less hour for instruction. When teachers have less time for instruction, they have to increase the pace of instruction and this means that students may not have sufficient time to organize the new information into increasingly complex cognitive structures. When this happens, students do not develop a complete understanding of the concepts and skills they have been taught, making it nearly impossible for them to remember these things for the test (or even for tomorrow's class).

What Can Schools Do About Standards-based Teaching?

Schools today are faced with a dilemma. On one hand, the state is telling schools to incorporate the standards into the curriculum and test students on a regular basis. On the other hand, there are major concerns with standards-based teaching, as noted above. So what should schools do in order to meet this challenge? Following are some suggestions regarding how schools could meet the requirements of ESSA, without having to resort to standards-based teaching.

Maintain a Broad Curriculum

It is extremely important that schools not cut back on their science, social studies, art, music, and physical education programs. Students need **science and social studies instruction** before they can effectively comprehend reading passages in these areas; otherwise, the information is too abstract for them, no matter how many comprehension strategies they have been taught. In addition, students benefit from experiences in **art and music** because research indicates that participation in these areas has a positive effect on cognitive development. For example, Spelke (2008) found that moderate-to-intensive music training had a positive effect on the spatial abilities of children and adolescents. Finally, students should be involved **physical education** classes. Citing the results of several recent studies, Viadero (2008) stated that there is now strong evidence that exercise can boost brain function because of how it puts the brains of children and adolescents in the best position to learn. This same argument could also be used to encourage schools to maintain a consistent recess schedule, because students need alternating periods of work and relaxation in order for their brains to function effectively.

Develop and Implement a Coherent Curriculum

Developing and implementing a coherent curriculum is best done by choosing math and science textbook programs that include a complete scope and a logical sequence of topics within the grade levels and across the grade levels. Traditional textbook programs have been developed by teams of educators and content specialists who have spent considerable time in planning the scope and sequence of their programs; thus, they are likely to include a complete set of topics that follow a logical sequence. Most textbook programs provide a curriculum grid which lists the topics addressed in the program and identifies the grade level in which each topic is to be addressed. It is relatively easy to evaluate the scope and sequence of the program by observing these curriculum grids.

As schools develop and implement a coherent curriculum they should *have a view toward the standards*. By their own admission, the standards were not meant to be adopted as the primary source for curriculum. According to the Common Core State Standards Initiative (n.d.), "Standards are not the curriculum. This initiative is about developing a set of standards that are common across states. The curriculum that follows will continue to be a local responsibility." The introduction to the Common Core Standards (National Governor's Association, 2010) makes a similar point, noting that, "These standards do not dictate curriculum" (p 5).

Even though the standards were not meant to be the primary source for curriculum, they are useful in providing general guidelines for schools as they update their curricula in math and science; therefore, schools should evaluate their textbook programs based on the standards in order to identify possible gaps. Then they should fill in those gaps with additional lessons that supplement the textbook programs. This is how the standards were really meant to be used.

Utilize Research-based Instructional Strategies.

NCLB legislation encouraged schools to conduct scientific research in order to determine and then utilize teaching methods that have been shown to be effective. According to Manna and Petrilli (2008), the term "research" is mentioned 216 times in the No Child Left Behind Act, and in more than half of those references, it is coupled with the phrase "scientifically based." ESSA legislation moved from the phrase "scientifically based" to "evidence based" (West, 2016, p 1). Under ESSA, evidence based includes experimental studies (strong), quasi-experimental studies (moderate), and correlational studies (promising)

Along those lines, research conducted over the past four decades has consistently supported the use of activity-based methods for teaching math and science. In math, activity-based methods involve discovery teaching and the use of manipulatives, while in science, activity-based methods include inquiry-oriented instruction and hands-on materials. It is noteworthy that there has been virtually no support in the research for the use of traditional approaches for teaching math and science. This is why Conley (2011) notes that the ideal results of standards implementation would be for schools to move away from a focus on traditional approaches toward a more engaging curriculum that will enhance students' cognitive abilities.

Avoid an Over-emphasis on Teaching Test-taking Skills

One of the most important aspects of the teaching and learning setting is "time on task." The more time students spend on task, the more likely they are to learn; therefore, schools should avoid placing an over-emphasis on teaching test-taking skills. Rather, they should use that time to help students learn important skills and concepts. A related concern is the time that many schools devote to taking practice tests. In some schools, one class day per week is devoted to taking practice tests. That is 20 percent of the instructional time available in a full week.

Conclusion

Neither No Child Left Behind nor the Every Student Succeeds Act require schools to narrow the curriculum, to adopt the standards as the primary source of curriculum, to use traditional approaches to teaching, or to implement a test-coaching program; however, these are things many schools have chosen to do as a result of misconceptions they possess regarding how to best prepare students to pass the proficiency tests in math and science, even though using these approaches is a disservice to teachers and to the students they serve. Schools should be encouraged to maintain a broad curriculum, develop a coherent curriculum, utilize research-based instructional strategies, and avoid an over-emphasis on teaching test-taking skills. If someone asks, "What about the tests?", explain to them that if they make these adjustments in their programs, their students will be better educated and, as a result, will also perform better on the tests."

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