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OurBlook interview with Dr. Angelo Collins, executive director of the [Knowles Science Teaching Foundation](#)



Trying to find good math teachers and good science teachers for our nation's schools ... is that one problem or two separate problems? Is there a shortage of either or both?

AC: I do believe there is a national shortage of both mathematics and science teachers at all levels. However, this shortage is seen most clearly at the local and regional level. Urban and rural districts experience more shortage than suburban districts. By some estimates, the U.S. will need as many as 250,000 new science and mathematics teachers within the next five years. Schools and districts without certified teachers address the problem by allowing teachers to teach subjects in which they are not credentialed or, in some instances, eliminate the course from the school's offerings.

I believe that what is necessary to educate and provide ongoing professional development for mathematics teachers differs from what is needed for science teachers. There are a number of reasons I believe this.

The place of mathematics in the public view of education is different from their view of the role of science in education. Mathematics has long been considered an essential element of U.S. education. We see it in the historical "readin', 'ritin' and 'rithmetic" to the recent No Child Left Behind legislation and the coupling of future national standards in mathematics and literacy with Title I funds. For both better and for worse, science does not hold the same place.

Math and science teachers follow separate tracks. Most states award a single credential in mathematics which allows a person to teach algebra or geometry or calculus. For science teachers, the certification is for biology or chemistry or physics or Earth science, not science.

Similar to the credential, there is one major professional organization for mathematics teachers ... the National Council of Teachers of Mathematics (NCTM). In science, while there is the National Association of Science Teachers (NSTA), there also is the National Association of Biology Teachers (NABT), and the American Association of Physics Teachers (AAPT) and the Education Division of the American Chemical Society (ACS) as well as several others.

These two disciplines are interdependent in the ways they support each other. Both have a component I will call conceptual and a component I will call procedural. But within these similarities what counts as a problem, what counts as valid evidence and argument and what are the possible and necessary applications differ.

At the **Knowles Science Teaching Foundation (KSTF)**, our efforts are to increase the number and quality of both high school science and mathematics teachers. Within the Teaching Fellowship Program mathematics, physical science and biology occur as separate, but parallel and interdependent strands. In each strand, the program officers who work with and mentor beginning teachers have degrees in the subject area, experience teaching the subject and advanced degrees in education.

To what extent should math and science be required in the high schools, and to what extent elective?

AC: The question gets at the more fundamental questions about the purpose for high school and who has the warrant to determine that purpose. Let me provide a very simplified view of the purposes for education that vie for prominence in American education. Some view the purpose of education as necessary to lead a full, rich, productive life; others view schools as the place to learn the skills needed for success in the workforce; a third view is that the purpose for schooling is to learn skills such as analysis, critical thinking and problem solving. While many would argue, myself included, that all three are necessary, different purposes play out in the design of curriculum, frameworks, standards or whatever tool is setting the vision for education at a given time and place.

Then there is the differentiation among the purposes for elementary school, middle school and high school. I believe that the focus of elementary school should be on learning how to learn and what it means to know and understand a topic, middle school uses the ability to learn to study topics of interest to students without a focus on what is necessarily discipline specific knowledge; high school provides opportunities for students to develop discipline-specific knowledge and to experience different disciplines.

Ideally, this focus on the disciplines enables students to acquire sufficient understanding and skill to function well in society to make judgments about their ability and interest in a discipline. There is a current focus on 'higher standards' which often translates into complex, abstract topics being introduced at lower and lower grades. While I think students often can accomplish more than some school and state policies ask of them, I

believe there is a difference between being able to recite an answer and developing a deep understanding of a concept.

Finally, at one period in American history, an eighth grade education was considered sufficient to be successful, and then a high school diploma was considered the terminal degree. Currently some post-high school education is seen as necessary. All this is background for considering what students should be required to study in school.

And so, to get to your question, if I were queen of curriculum, I would require introductory high school courses in both mathematics and in science that focus on the very nature of each discipline and a minimum of one elective in each discipline that focuses on a single aspect of the discipline in an integrated manner. (I know a required elective is an oxymoron.) Students could, of course, take several electives if they chose.

How do you feel about separate high schools that specialize in math, science, engineering and technology?

AC: It depends on a number of factors. The first goes back to the previous answer about what one believes about the purpose for schooling. Another is the design of the curriculum and instruction in the school. I have visited STEM high schools where students were engaged in science inquiry that required skill in mathematics. The students designed tools to seek answers to problems, and learned to write and speak eloquently and persuasively. They had access to equipment that some community colleges do not have. Underlying this focus on STEM were requirements in literature, fine arts and languages. Such a school design allows students to develop both a general background and specialized skills.

However, STEM-focused schools raise some concerns for me. One is that such schools become a substitute for tracking students. Another concern is if we know enough about how these four subject areas interact to decide which students are really the best candidates for such schools. A third concern is whether 13-year old students know enough about the topics of STEM and about themselves to make such life transforming decisions. Finally, at all times, districts and states need to make difficult decisions about the allocation of resources and if funding such a STEM-focused school deprives other students of the opportunity to understand the science and mathematics they will need to make valuable personal and social decisions, that would be a grave concern.

As a side note, I believe that schools that focus on fine arts are equally valuable for the future of our country.

(Editor's note: STEM stands for Science, Technology, Engineering and Mathematics.)

Are math and science more amenable to online learning than the liberal arts? Would you like to see them go in that direction or do you prefer the teacher right there?

AC: While you may think I have only one idea, the answer goes back to the purposes for schooling. I have seen a few examples of physics classes where students heard a lecture, did some reading, answered some questions, solved some one-correct-answer problems online and had a 'qualified adult' in a classroom to oversee some experiments. And while I won't say that a student cannot develop a deep understanding in this way, the discussion of evidence and persuasion of others based on the evidence which underlies understanding is more difficult to achieve.

If science is to focus on problem solving, model building, argument and persuasion, then students need places to collect data, analyze and discuss the data, and reach conclusions. Manipulating equipment and holding discussions about data and evidence online seems a little tricky to me. Of course, I have seen advancements in communication technology that the limitations I imagine could be overcome in the future.

How are U.S. high schoolers faring compared to students from other nations in global tests measuring math and science?

AC: There are two major global tests ... TIMSS and PISA. TIMSS is the Trends in Mathematics and Science Study and PISA is the Programme in International Student Assessment. While TIMSS aims to assess what students learn in school, PISA aims to assess how well students are able to use school knowledge to function in a world beyond school. Students in the U.S. do not do well in either test. However, only occasionally do such assessment programs do simultaneous studies of the culture and context of schooling in the countries whose students take the assessments. While I would like to see U.S. students do better and while it is not politically popular to say so at this time, I am not convinced that these assessments are measuring what is really worth knowing in science and mathematics. It is difficult, complex and costly to design an assessment that uncovers students' thinking on questions that have multiple possible correct answers. Often, in order to make comparisons across countries, the questions on such tests are limited in the depth and complexity they probe.

Is math and science education, or lack of it, a factor in the formation of voucher systems and charter schools?

AC: I have no idea. My knowledge of such schools is limited to what anyone can read in the popular and education press.

You've mentioned the need for mentoring and camaraderie between teachers. Please give us your thoughts on that.

AC: Here at [KSTF](#) we believe that teaching is complex and requires study and reflection which takes a long time to learn. There have been many attempts to define all the knowledge and skill a teacher must have from knowing the subject and how to enable students to learn to how adolescents in general and then each individual student learns. They need to know what motivates each student, how to assess what students are learning and what they have learned, how to plan lessons, how to maintain a safe and orderly

classroom and how to work with the parents and the community, to name just some areas in which teachers need deep understanding and skill. They also need to know how to reflect on and learn from their practice.

It is so helpful for an early career teacher to have an experienced colleague who can provide resources, suggestions, an extra pair of eyes in the classroom and who can ask the right questions to promote professional growth. It is also valuable for teachers at all stages of their careers to have colleagues with whom they can discuss the complexities of teaching ... what worked, what didn't, where to get additional ideas and inspiration. This collegiality goes well beyond camaraderie to include the concept of critical friends, colleagues who understand what the teachers are teaching, who they are teaching and the context in which they are teaching and then help one another improve the instruction and student learning.

What is your general view on the future of education in America ... will it get better or worse?

AC: I am amazed at the accomplishments of KSTF Teaching Fellows and the impact they are having on students, one another and their colleagues. Several have designed and conducted instruction on sound by having their students make and play musical instruments. Others have taught about energy by having their students research and design bicycle generators for their schools. Still others have introduced new ways for teachers to work together.

My list of their accomplishments can go on and on. There have been at least 30 presentations by KSTF teaching fellows at national or regional meetings such as the National Science Teachers Association or the National Council of Teachers of Mathematics; 11 fellows have received awards from external agencies such as the Noyce Foundation, the Woodrow Wilson Foundation or Coca-Cola; 10 fellows have published either in peer reviewed journals or by invitation; 10 have assumed positions of leadership such as department head or specialty team leader in their own schools; 10 have formally taught other teachers such as in courses at a local university or district workshops; six are mentoring practicing or first-year teachers in their schools; and six are engaged in research in conjunction with a nearby institution.

And then there are the successes of the students of these young teachers which range from a greater than 90 percent pass rate on the state assessment in chemistry to winning a robotics competition, an engineering competition, and the state Science Olympiad. And don't forget the students who raised funds for computers for a school in Uganda and learned about the needs of another country because their teacher delivered the computers and taught other teachers how to use them. And then there is the KSTF alum who recently returned from the South Pole where he was doing research and considering curriculum and instructional implications of the work. These young, idealistic, energetic teachers give me hope.

However, at a national and local policy level, I am less hopeful. I taught during the 1960s and '70s when there was great emphasis in both the content and process of science and the importance of science laboratories in high schools. My high school sophomores had lab every week and did an independent research project each year. I have worked on the design of complex assessments that required students to reason and not just recall. I worked on the 1990s science standards and wrote about the importance of inquiry and the nature of science and cross-cutting themes.

The recent and current discussions I hear about the national goals for education seem to be focused on students being taught increasingly complex concepts without the necessary prior knowledge and then measuring what the students can recall in an efficient and inexpensive manner. While this approach might lead to high test scores on internationally benchmarked assessments, I am not convinced that it will lead to deep understanding, the ability to evaluate evidence and make arguments, critical thinking, problem solving and creativity. There also seems to be an emphasis on getting teachers into classrooms with a parallel focus on what teachers need immediately and in the long term to keep them in the classroom enabling students to learn.

*(The **Knowles Science Teaching Foundation** in Moorestown, N.J., was founded in 1999 to support high school math and science teachers. Dr. Collins taught high school science for 15 years and also has held posts with Stanford University, the National Academy of Sciences and Vanderbilt University. She has a B.S. degree from Marian University at Fond du Lac, a master's from Michigan State and a Ph.D. from Wisconsin.)*