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Issue Theme: *"Illinois Responses to the Next Generation Science Standards Movement"*

Abstract

National STEM standards (science, technology, engineering, mathematics) that states use as guides in developing state standards date to the mid-1990s. Since that time the United States has continued to lag behind other nations in the preparation of a workforce with strong backgrounds in these fields and many Americans lack even rudimentary STEM knowledge. This despite the fact that science, engineering, mathematics, and technology permeate every facet of modern life and are key to meeting many of humanity's pressing current and future challenges. Many argue that America's future vitality will be determined by our success in improving educational preparation in these areas.

According to the National Academy of Sciences, the movement to establish next generation science standards (NGSS) is rooted in the belief that proficiency in science involves the mastery of competencies developed in scientific and engineering practices, crosscutting concepts that unify the study of science and engineering through their common application across fields, and core ideas developed in four disciplinary areas--life sciences; physical sciences; earth and space sciences; and engineering, technology and other applications of science.

K-12 science education should reflect real world connections among the sciences and their applications in engineering and technology, include both grade standards and stronger science standards for high school graduation, and feature partnerships with post-secondary education, especially collaborations between and among K-12 and higher education faculties in science, technology and mathematics, as well as teacher education. Achievement of next generation science standards will require increased college-level collaboration between science and teacher education faculty, redesign of teacher preparation programs, and significant attention to faculty and teacher professional development. This issue of *Success in High-Need Schools Journal* explores responses to the NGSS movement in Illinois.

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Publisher's Column: Responses to the New Next Generation Science Standards
by Jan Fitzsimmons, Ph.D.

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While the Next Generation Science Standards (NGSS) support the idea of immersing students in complex thinking about critical concepts in science and engineering and their connectedness across disciplines, the element of the new standards that uniquely identifies NGSS from previous frameworks for K-12 science learning is the element of student engagement. Like the popular **NIKE** slogan—*Just Do It*—NGSS is explicit in making students active agents in their own science learning. In this issue, readers are guaranteed an opportunity to understand the new Next Generation Science Standards from a variety of perspectives ranging from teachers to administrators to college faculty to the private sector and from research to practice to real world application.

In her article, *Impact of the Next Generation Science Standards in Illinois*, **Carol Baker**, one of a number of individuals on the NGSS writing team, describes the new standards as moving science learning from "memorizing units of information" to "active, relevant participation in science." The "goal" she writes is "to teach students to solve problems" with the hope "that more students will be engaged with science and interested in choosing a career in science or engineering." Read Baker's article to learn more about the opportunities she sees to achieve these aspirations.

State Farm has long been a staunch supporter of teachers and **Kathy Payne**'s column emphasizes the importance of teaching and "private sector engagement" in supporting the teaching profession. State Farm and Payne recognize the importance of recruiting and retaining great teachers to implement more rigorous standards with fidelity. They urge others in the private sector to commend teachers and support the development of strong teachers for all children! To learn more about the argument Payne establishes in her support of teachers and their development as professionals, review her column.

Wilson and Kuck describe a successful program at Benedictine University that recruits and prepares talented candidates to teach science in the tradition of the new Next Generation Science Standards. The article supports the importance of "experience," as well as "scholarship dollars," to grow a pool of strong science teachers. Like Payne, Wilson and Kuck also emphasize the importance of teacher development to retain talent. In this article, the authors not only share their ideas about best ways to recruit and prepare science teachers, but they also share ideas about mentoring new teachers in person and online to help teachers grow and develop. In addition, the authors outline a study to follow candidates into the classroom to study "the impact of teacher learning and style on student learning." Research that follows teachers from the "teacher prep" and science content classroom to the K-12 classroom is critical to advance best practices that are rooted in research and evidence-based. This work has often been overlooked and underfunded in education. Wilson and Kuck provide a great example for all to review as new programs are developed to integrate the NGSS in teacher preparation and the K-12 classroom.

Clemente's article, *Start at the Beginning: Unpacking Experience to Gain Insight on How to Teach Science*, offers another rich opportunity to consider best practices for teacher preparation. Clemente argues that to best prepare candidates to effectively integrate the Next Generation Science Standards with instruction, we must understand their own context for learning and appreciating science learning. In this autobiographical account Clemente describes the "deep dive" she takes with students in science methods courses to grow her understanding of her teacher candidates as science learners. The author explains that this activity not only helps her tailor learning for teacher candidates, but also that as a result teacher candidates begin to consider how the way each of them learned serves as a context for how they think and implement instruction in their classrooms. A review of this article reveals evidence for affecting a change in thinking and teaching the new NGSS.

In interviews with teachers, **Anna Laky**, Maine East High School, and **Pam Wagner**, North Lawndale College Prep, the teachers discuss the NGSS and its impact or potential impact on their classes. Laky, notes that "NGSS presents a new way of teaching, as well as a new way of thinking and interacting with the content (science) for students." Wagner explains that she has been exploring NGSS to see how NGSS would "support the scientific thinking" in which she expects her students to be engaged. She highlights the active nature of the NGSS vocabulary using NGSS examples like "analyze," "plan and conduct," and "communicate scientific information." Wagner also contends that the NGSS use of active vocabulary affirms her belief that "every student in her class is a scientist who needs to collaborate and think scientifically." Read Laky and Wagner's columns to get insights to how two teachers are engaging in the implementation of the NGSS.

In an interview with **Paul Goldberg**, the principal of John Muir Literacy Academy in Schaumburg, Illinois, Goldberg notes the important abilities of new teachers to "plan and collaborate, teach and learn, develop a positive classroom environment, and act as professionals." Goldberg advances the idea that these skills are integral to new teachers' ability to embrace rigorous standards like the NGSS and successfully implement them in instruction.

Finally, **Kolar, Phillips and Martinez** share perspectives on *Preparing Students for Future Scientific Expertise* and address need, research on best practices and their own Illinois Mathematics and Science (IMSA) Fusion program, an exemplary outreach program impacting teacher and student STEM learning. Like the NGSS, integral to the IMSA Fusion enterprise is the understanding that "science is more than a body of knowledge that students must memorize…" rather the authors argue that "the goal of science education …should be a focus on students working in classrooms using practices that develop their understanding of the cross-cutting concepts of science and engineering" (an integral component of the NGSS framework).

Explore this issue of *Success in High-Need Schools*, **Responses to the New Next Generation Science Standards,** as you consider how your students will be introduced to science and grow as consumers---and perhaps producers of new scientific understandings to problems yet to be defined.

Impacts of the Next Generation Science Standards in Illinois
by Carol K. Baker, Ed.D.

Author Bio:
Carol Baker, Ed.D., was a member of the writing team for the Next Generation Science Standards (NGSS). She has also worked closely with reviewers from the Lead State Review Team in Illinois and the Illinois Adoption Team, and is a member of the leadership team for Building Capacity for State Science Education in Illinois. She has worked with state officials on plans for Illinois NGSS adoption and implementation. Additionally, she conducts many workshops and presentations on NGSS both locally and nationally. Currently, Carol is the Director of Curriculum for Science and Music for Community High School District 218 in Oak Lawn, Illinois. She also serves on advisory boards for both Wards and McGraw-Hill.

Abstract
Illinois will soon join other states in the adoption of the Next Generation Science Standards (NGSS). In order to meet what the writers of NGSS intend, K-16 science education in Illinois will need to undergo changes. Today's science teachers in Illinois are using an antiquated set of standards that emphasizes the memorization of vast amounts of knowledge and do not reflect the technological revolution of the last fifteen years. The NGSS emphasizes students being able to do science, rather than just learn about science. The focus of NGSS is on engaging today's science students in active, relevant participation in the science classroom that mimics the work of scientists and engineers. The goal is to prepare today's students to solve the problems of tomorrow. The transition to the NGSS will be significant for both students and teachers in Illinois and around the country.

Introduction
Following on the heels of the Common Core, the Next Generation Science Standards are intended to revitalize and improve American science education. Statistics show that the United States is losing its competitive edge globally with regard to science and technology. Our shrinking share of patents and diminished share of high tech exports, as well as continued lagging achievements of US students in science, are troubling statistics for a country that has long seen itself as a world leader in innovation. We still may have the best science and engineering university programs in the world, but we cannot fill our own university science and technology classrooms with American students. A quick walk around the engineering building of any major university and one will see that many foreign students are filling the seats that American students have chosen not to. What have we done to de-motivate students from careers in science and technology? Well, it's not really what we have done, but more about what we haven't done. No Child Left Behind (NCLB) has forced schools to spend more time on math and reading; for many schools, that means taking away time from science. Science in many elementary classrooms around the country has become little more than a worksheet activity once a week; hardly the engaging type of lessons and experiences that motivate students to pursue careers in science and engineering. The challenge for the Next Generation Science Standards is to lead K-12 schools to better science education programs. How significant the changes will be will vary from state to state, even from school to school, based on current curriculum and classroom practices. Illinois has begun the adoption process and is expected to finalize adoption in late winter of 2014. Once the implementation

process begins, most schools in Illinois will need to make significant changes in their current science programs.

Development of the Next Generation Science Standards

Most states have been using K-12 science standards that were written in the 1990s. In Illinois, the current set of science standrds were adopted in 1997; the research used in the creation of these standards was collected in the late 1980s. The technological revolution has changed life significantly since the late 1980s! At that time, there was an emphasis on learning large amounts of scientific information. Teachers-in-training likely remember the emphasis placed on memorizing vast amounts of material as they progressed through college courses. Needing to look up such factual information meant digging through books, heading off to a library, or looking through an out of date encyclopedia. But today, we live in different world—a Google and a Wikipedia society. No longer does the emphasis need to be on memorization, as we have the ability to acquire information we need to know instantaneously. And since knowledge grows and changes every day, science education needs to move away from requiring the memorization of facts and knowledge and instead, teach kids how to ***do*** science. In order to be prepared to solve the problems of tomorrow, today's students need to be able to question, think, analyze, apply, and communicate; knowledge can be looked up and easily acquired, the latter are active skills and practices that can only be developed over time.

The Next Generation Science Standards have not completely done away with science knowledge! Instead, they have reduced the number of concepts that must be taught in K-12 schools to a realistic set of core ideas that will allow students to build deep conceptual understanding over time. The NGSS "Crosscutting Concepts" will assist with this, helping students make connections from one grade level to the next and from one discipline to the next while using the "Science and Engineering Practices" to strengthen their ability to do science. These three dimensions, combined together, will provide students with a strong base to be able to navigate whatever the world becomes in the future.

NGSS in Illinois

How will these new science standards affect schools in Illinois? At the time of the writing of this article, Illinois was already in the process of adopting NGSS for Illinois. Taking a closer look at just how NGSS compares to the current Illinois Learning Science Standards, one can see that differences are extensive (See Figure 1 and Figure 2). The Illinois Learning Standards for Science in place use words like "explain," "describe" and "identify." Such vague verbs do not specify instructional methods from which teachers should choose. If the end result for a student is merely to be able to explain something, there is little or no encouragement for the teacher to use activities or laboratory investigations as part of the instruction. Teachers can simply "explain" the knowledge themselves by lecturing to students. Sadly, in many classrooms across the state of Illinois, students are engaging in very little hands-on science. But in the NGSS, performance expectations specifically dictate how students should demonstrate their ability to do science applying the Science and Engineering Practices. For example, "Analyze and interpret data, construct an argument with evidence and develop and use a model," (Achieve, NGSS 2013) cannot be taught through lecture. Teachers must construct learning experiences in which the students will be actively engaged in doing science via these practices.

Figure 1: Current Illinois Learning Standards for Science (ISBE)

B. Know and apply concepts that describe how living things interact with each other and with their environment.

EARLY ELEMENTARY	LATE ELEMENTARY	MIDDLE/JUNIOR HIGH SCHOOL	EARLY HIGH SCHOOL	LATE HIGH SCHOOL
12.B.1a Describe and compare characteristics of living things in relationship to their environments.	**12.B.2a** Describe relationships among various organisms in their environments (e.g., predator/prey, parasite/host, food chains and food webs).	**12.B.3a** Identify and classify biotic and abiotic factors in an environment that affect population density, habitat and placement of organisms in an energy pyramid.	**12.B.4a** Compare physical, ecological and behavioral factors that influence interactions and interdependence of organisms.	**12.B.5a** Analyze and explain biodiversity issues and the causes and effects of extinction.
12.B.1b Describe how living things depend on one another for survival.	**12.B.2b** Identify physical features of plants and animals that help them live in different environments (e.g., specialized teeth for eating certain foods, thorns for protection, insulation for cold temperature).	**12.B.3b** Compare and assess features of organisms for their adaptive, competitive and survival potential (e.g., appendages, reproductive rates, camouflage, defensive structures).	**12.B.4b** Simulate and analyze factors that influence the size and stability of populations within ecosystems (e.g., birth rate, death rate, predation, migration patterns).	**12.B.5b** Compare and predict how life forms can adapt to changes in the environment by applying concepts of change and constancy (e.g., variations within a population increase the likelihood of survival under new conditions).

Figure 2: Sample of Next Generation Science Standards (Achieve, NGSS 2013)

MS-PS4 Waves and Their Applications in Technologies for Information Transfer

MS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]

Another emphasis in NGSS that is not present in the current Illinois Learning Standards for Science is the idea of students building a coherent understanding of science as they progress from one grade to the next. NGSS *Appendix E: Progressions Within the Next Generation Science Standards* details how concepts are to be developed over K-12 science education. According to the vision presented in *A Framework for K-12 Science Education,* "(NGSS) is built on the notion of learning as a developmental progression. It is designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works. The goal is to guide their knowledge toward a more scientifically based and coherent view of the natural sciences and engineering, as well as of the ways in which they are pursued and their results can be used." (NRC, 2012).

Illinois Learning Standards for Science were organized and tested in grade bands. This gave individual schools some freedom to determine exactly when a particular concept would be covered. A school could decide, for example, if the rock cycle was to be taught during 3rd grade or 4th grade. Unfortunately, this choice has caused many problems within K-8 schools in Illinois. Many elementary school districts do not have the funds to employ a science curriculum specialist to oversee the creation of a science curriculum structure. For many teachers, their curriculum is simply to cover whatever is in the book they have been given to use. Additionally, when given the choice, teachers are likely to gravitate toward topics that they feel most comfortable teaching. Because a firm structure was not set in Illinois, teachers may also take on the attitude that a concept will be taught the following year by the teacher in the next grade. Allowing schools to make choices about when science topics could be taught has resulted in some students not receiving certain content at all or repeating content because two different teachers both decided to cover it. Also, allowing schools to make these choices does not reflect the idea that some concepts should be taught before others so that students gain a clear organized picture of how the world works.

The fact that Illinois has tests for science that only occur in grades four, seven and eleven further compounds the problem. Fourth and seventh grade teachers experience high stress in trying to determine what has been taught to their students up to these check points and feel the need to alter their instruction and cram in more than they should have to cover or their students won't score well on the science portion of the ISAT.

The writers of the both the Framework and NGSS paid close attention to current brain research regarding the ability of students to master concepts over time given a structured pathway that allows students to be introduced to science concepts at the appropriate time in their brain development. NGSS is explicitly laid out for K-5 so that in those critical, early years students are exposed to science that not only builds on previous concepts taught, but aligns with what they can understand conceptually. Emphasis has moved away from allowing and encouraging students to memorize facts that they cannot yet comprehend, and moving toward building deep understanding over time.

Teachers across all grades will need tools to help them master how to teach NGSS. Roger Bybee comments in his book, *Translating the NGSS for Classroom Instruction,* "Educators should have in-depth knowledge of the BSCS 5E instructional Model (or a similar model that has a rigorous research base) and the patience to familiarize themselves with the *NGSS* and *A Framework for K-12 Science Education* (NRC, 2012). A strong instructional model can provide the structure for the teacher and student roles, while NGSS provides the content in context with performance expectations." (Bybee, 2013)

K-5 teachers may find the transition to NGSS more difficult than any other grade levels. Due to the design of most teacher education programs, they have not been well prepared to lead students in doing science to the depths laid out in NGSS. This is the group that is likely to need the most professional development and support; they will need to learn and experience more science themselves before they can bring it to their students. Because NGSS is laid out grade by grade, K-5, teachers will find themselves having to teach concepts they have never taught before or that they have little or no knowledge of.

High school teachers will likely find that once they understand the new standards and feel comfortable about what the NGSS is asking them to teach, the actual process of implementation is more difficult than first anticipated. Teachers who have developed fabulous PowerPoint lectures and admit to instructing in dimly lit classrooms with quiet students listening, taking notes and answering an occasional question will have the most changes to make. NGSS supports the notion of a student centered classroom, where students are demonstrating their knowledge of NGSS through the Science and Engineering Practices. Transitioning to this kind of teaching is not just about writing a few new lesson plans, it is a complete overhaul in the philosophy of teaching and learning science. Changing old habits is hard, and could be even harder for those teachers who were themselves taught in that same lecture-based format.

Current teachers who went through high school in the era of NCLB were likely taught in classrooms where there was an emphasis on covering vast amounts of content; science teachers who did little lab work in school themselves likely are teaching that same way and will need to make the most changes. Those teachers that went through school and began teaching prior to the focus on the current standards may actually feel that NGSS is a return to the good science teaching practices of the past. They may see it as a return to focusing on students being able to spend in-depth time on a concept and thoroughly exploring it through a variety of methods that model the real work of scientists and engineers. Instruction of NGSS focuses on the Science and Engineering Practices; teachers who continue to use activities like science fair projects as part of their curriculum are already dabbling in the use of these practices and may feel at least some comfort in knowing that they can use their knowledge of those experiences to build upon.

Teachers may also face some resistance from some students. If students have been in a passive learning environment in their high school science classroom, expecting them to walk in one day ready to start actively working and performing science is likely not going to happen. Some teachers have seen resistance from some of high performing school students who have done reasonably well in science classrooms by being able to complete worksheets, take notes during PowerPoint lectures and memorize science facts for tests. They have been successful in this passive learning environment and may not be happy that now they have ***do*** science. They may want the teacher simply to tell them what they need to know so they can memorize it and move on. Also, students that are unmotivated to do well in school and have been able to "hide" in those dimly lit classrooms may resist NGSS. The Performance Expectations of NGSS clearly describe what students need to be able to do, and passively refusing to participate in the activities of a science classroom will no longer be an option. K-12 teachers will find that the first few years of implementation of NGSS will be the hardest. Students may need to be re-trained about how to be serious science students. Coming to class "ready to work" will have new meaning because students will be expected to actively think and do as scientists and engineers do. Transitioning from the type of instruction supported by the current Illinois Learning standards for Science to NGSS is like transitioning from watching a sporting event to actually playing the sport.

Assessing NGSS

Teachers have found that upon reading the Performance Expectations for their grade/subject, assessing their student's mastery of these is yet another challenge. Performance Expectations that require students to create models or use evidence are not easily assessed using a traditional paper and pencil test, especially a multiple choice assessment. Traditional multiple choice assessments are useful when needing to measure whether students have mastered factual knowledge, but since NGSS requires that students be able to do science using the Science and Engineering Practices and make connections via the Crosscutting Concepts while focusing on a smaller set of Disciplinary Core ideas, new assessments will need to be developed to address all three of these dimensions simultaneously. The National Academies of Science recently released a lengthy document addressing this issue. The paper is titled, *Developing Assessments for the Next Generation Science Standards* (NRC 2014), and is meant to guide those who will develop both small scale assessment (classroom) and large scale assessments (state). The paper lists a set of characteristics that these new assessments must meet:

Include multiple components that reflect the connected use of different scientific practices in the context of interconnected disciplinary ideas and Crosscutting concepts;

Address the progressive nature of learning by providing information about where students fall on a continuum between expected beginning and ending points in a given unit or grade; and

Include an interpretive system for evaluating a range of student products that are specific enough to be useful for helping teachers understand the range of student responses and provide tools for helping teachers decide on next steps in instruction. (NRC, 2014)

The report goes on to support the development of simulations as part of the assessment process. Simulations allow students to demonstrate their ability virtually to complete investigations via several decision making steps. Other organizations, like NAEP (National Assessment for Educational Progress), have already begun to use simulations. The report also supports the use of smaller scale classroom measurements such as portfolios and other performance assessments to truly measure a student's progress through NGSS.

High School Graduation Requirements

The Next Generation Science Standards will likely require three years of coursework at the high school level for most students. NGSS Appendix K, *Model Course Mapping*, lays out several examples of how middle schools and high schools could organize the Performance Expectations by course or grade level. Many states already have a 3 or 4 year science requirement but Illinois currently only requires two years of science at the high school level for graduation. School boards in many school districts across the state of Illinois already added a third year to their graduation requirement feeling that the state requirement was not adequate to prepare students for college level work. Illinois plans to adopt the NGSS first, then conduct research on the need for adding the requirement of the third year. Smart high schools that still only have a two-year requirement should start planning now for the impact that adding a third year will have. The need for more science teachers, more money for science materials and additional lab facilities will likely impact schools across the state.

What About Colleges and Universities?

Though the changes in science teaching and learning will be extensive at the K-12 level, implications for higher education are looming as well. Both teacher preparation programs and science major programs will need to take a closer look at what they are currently offering students. With regard to teacher preparation programs, the future K-5 teacher will need more science coursework to be able to teach science as laid out by NGSS. Teachers-to-be will need significant instruction on the three dimensions of NGSS and will need to acquire a greater depth of knowledge themselves of the science content for their grade level. Many elementary teachers are not comfortable with students using laboratory materials and performing experiments. Further training and instruction in science concepts and methods will be needed to help them reach the comfort level they need to have in order to be able to cover NGSS. For teachers already in the classroom, unit school districts could make use of the expertise of their high school teachers to assist in revising curriculum and instruction at the lower grades and be a resource to those elementary teachers who find NGSS a substantial challenge. High schools in non-unit districts should consider stepping up their articulation efforts and partnering with feeder schools to share their expertise as well.

Obviously, one of the hopeful outcomes of NGSS is that more students will become intellectually engaged with science and interested in choosing a career in science or engineering. If K-12 schools get it right, they will be sending highly motivated students who are well prepared to continue the journey of studying science and engineering in college. Students will expect to continue learning and doing science as NGSS prescribes. Colleges and universities who currently place freshmen science and engineering students in large lecture halls with only limited time per week in a laboratory setting may want to re-examine their course structure. Science students will come to college expecting more hands on opportunities, and will be better prepared to go right into higher levels of laboratory work, research, and design. Colleges and universities need to consider the possibility of restructuring their current programs to offer students more opportunities to do the kind of investigative science that is typically reserved for graduate school. If they don't, we will be at even a greater risk for loosing these highly motivated students. Students who are science majors will enter their freshmen year expecting to continue to build upon the engaging science and engineering they have experienced in high school.

The report, *Engage to Excel: Producing One Million Additional College graduates with Degrees in Science, Technology, Engineering and Mathematics* released in 2012 by the President's Council of Advisors on Science and Technology, details the vast numbers of American students who enter college with a STEM major, but change majors during their freshmen or sophomore year because of lack of engaging experiences at the college or university level. The report declares that teaching and course design at the university level must change if we are to keep our best and brightest students in these demanding majors, "To create vibrant science classrooms that effectively transmit knowledge and develop the intellectual attributes of scientists, college faculty must overcome the inertia of the historical habits passed from generation to generation." (PCAST, 2012) Additionally, "One way to engage and, therefore, retain students in STEM subjects is to involve them in contemporary, authentic research during the first two years of college." (PCAST 2012) The report details the need to move away from the model of hundreds of students sitting in a lecture hall and move toward providing active classroom and research experiences for students during their first two years of college. Within a few years, students will be heading off to college having experienced NGSS at the high school level; if colleges and universities do not plan now to provide engaging experiences that allow them to continue the work of NGSS, we may see an even greater number of students leaving STEM majors than ever before. But college programs restructured correctly could mean that we can finally start cultivating

STEM students to be creative thinkers with strong science and engineering backgrounds ready to solve the problems of tomorrow.

Conclusion

The Next Generation Science Standards provide the K-16 world of science education a tremendous opportunity to enable all students to gain a comprehensive science education that will not only prepare them to be well informed citizens, but also to be able to pursue science and engineering courses and careers. But the changes for Illinois science programs will be substantial and science teachers at every grade level must do their part to insure that all students acquire the consistency and progression of science knowledge. This is a tremendous responsibility, but preparing today's students to be tomorrow's problem solvers is challenge with enormous benefits for the United States and the world.

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The Next Generation: Supporting STEM Initiatives

by Allison K. Wilson, Ph.D. and Cynthia L. Kuck, Ph.D.

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Abstract
Although the supply of new teachers in Illinois is considered fairly robust, teachers of mathematics, physics and/or chemistry rank in the top 10 for district-reported shortages. Benedictine University has been awarded a five-year Noyce Teacher Scholarship grant to increase the number of science, technology, engineering, and mathematics (STEM) teachers who earn secondary teaching licensure. Scholarships will be awarded to 27 juniors and seniors majoring in STEM and pursuing a career in teaching and 33 STEM professionals who earn their certification through Benedictine's alternative certification program. The ultimate goal is to develop an inquiry-based teacher training framework aligned with the Next Generation Science Standards (NGSS) that creates an inspirational learning experience fore preparing future secondary STEM teachers for success in a variety of challenging educational settings.

Introduction
The implementation of the Next Generation Science Standards (NGSS) will require an extraordinary effort by teachers, school administrators and ancillary support systems to impact and improve students' science literacy Because colleges and universities prepare future teachers and provide ongoing professional development, they must play a significant role in the successful implementation of the new standards.

The effort to implement NGSS faces considerable challenges, one of which is the funding of implementation. Since the movement to establish the NGSS is not a federal mandate, no monies have been specifically allocated for implementation. However, existing programs funded at the federal level can be used to promote the establishment of different facets of the NGSS. The Robert Noyce Teacher Scholarship program is one such venue (NSF, 2014). This National Science Foundation (NSF) program was established in 2002 to respond to the critical need for K-12 teachers of science, technology, engineering and mathematics (STEM) by encouraging talented STEM students and professionals to pursue teaching careers in elementary and secondary schools. It was reauthorized in 2007 and 2010 under the America COMPETES Act (P.L. 110-69) and the America COMPETES Reauthorization Act (P.L. 111-358) and addresses the specific goal established by the President's Council of Advisors on Science and Technology to ensure "the recruitment, preparation and induction support of at least 100,000 new STEM middle and high school teachers who have strong majors in STEM fields and strong content-specific pedagogical preparation, by providing vigorous support for programs designed to produce such teachers over the next decade" (PCAST, 2010). The Noyce program provides scholarships and programmatic support to recruit and prepare STEM majors and professionals to become K-12 teachers.

In Illinois, the need for additional STEM teachers is highlighted by the number of unfilled positions (ESD, 2011) reported by public school districts. In 2010-11, math had 42.1 unfilled positions, followed by physics (19.5), chemistry (9.7) and biology (4.7) with the majority of these positions located in the Chicago School District. Physics, chemistry and mathematics all ranked in the top 10 disciplines for district-reported shortages of qualified applicants in Illinois. Such shortages have been consistently identified since Illinois began to track and report them in 2000.

An integral part of the Noyce program is to increase the number of K-12 teachers with strong STEM content knowledge who are committed to teach in high-need school districts. High-need school districts are characterized by at least one of the following: "a high percentage of individuals from families with incomes below the poverty line; a high percentage of secondary school teachers not teaching in the content area in which they were trained to teach; or a high teacher turnover rate." (NSF, 2014). In order to meet this goal, there is a requirement that scholarship and stipend recipients must teach a minimum of two years in a high-need school district for every year of monetary support received. Loan forgiveness programs such as the Noyce program and *Teach for America* (TFA, 2014) have been used to promote new teacher recruitment. Liou (2010) found that Noyce scholarships promoted commitment to complete a licensure program and teach in high needs schools and programs. However, forgivable loan programs must provide experiences to encourage this commitment or it becomes just a tool for increasing numbers of STEM teachers.

Benedictine University was awarded a five-year Noyce grant in 2013. It is a Catholic university in the Benedictine tradition that provides a values-centered liberal arts education enriched by its excellence in science. Benedictine University has been recognized as one of the most productive undergraduate institutions in the country for the rate at which its graduates later earn doctorates in all fields of the sciences. It also has a long history of teacher preparation for careers in public, parochial and private schools in Illinois and across the nation. As such, the Noyce grant will be used to build on current programs in education and the sciences in order to ensure that all students have access to high quality STEM teachers (BEST, 2013). .

In addition to the undergraduate teacher training programs, Benedictine offers an alternative certification program (Alt Cert) for STEM professionals who express an interest in teaching science in grades 6-12. This program is designed for individuals who have earned at least a bachelor's degree in a STEM field and who possess at least five years of related work experience. The Alt Cert program is a cohort program that is currently 14 months in duration and includes an orientation, an intensive course of study in educational theory, instructional methods and teaching practices during an 8-week summer session. Participants obtain full-time, paid internships in selected middle schools or high schools and are supported by mentor teachers and University faculty who provide feedback and assistance throughout the year. The cohort is immersed in an intensive, problem-based program and ongoing professional preparation via regularly scheduled seminars and workshops throughout the initial teaching year. Successful completion of the program leads to an Illinois type 09 certificate and 24 hours of graduate course credit towards a master's degree in education at Benedictine University. The Alt Cert program will be revised in the next year to reflect updated Illinois State Board of Education (ISBE) requirements.

As with all Noyce Teacher-Scholarship grants, at least 75% of the 1.2 million dollar award will be used to support teacher education in the form of scholarships, stipends and internships. Twenty seven, 2-year scholarships are planned to be awarded to undergraduates majoring in mathematics, physics and chemistry and pursuing a career in teaching over the 5 year period. In addition, 33 1-year stipends will be awarded to STEM professionals pursuing teaching certification in the Alt Cert program. Over the period of the grant, at least 60 new math and science teachers are projected to be licensed to teach in high need schools and school districts.

Recruitment

In addition to offering scholarships, Benedictine uses a variety of methods to recruit candidates from the sciences into its teacher education programs. Methods that are used include the following:

- Early field experiences and short-term internships,
- Career awareness, and
- Learning assistants

Early Field Experiences

An effective method of recruiting candidates into teaching is through internships in education. Benedictine offers internships for tutoring of students in high-need situations through established partnerships with schools. A second opportunity for students to experience teaching of problem-based learning (PBL) is through Benedictine University's Sleuths summer program (BU, 2013) in conjunction with alternative certification program activities. Students in grades 5-9 come together for 4 days to work on solving a messy problem such as:

- What causes malformed frogs and are there any in Illinois?

- Under what conditions might we send teens into space?
- What role will alternative fuel vehicles play in future transportation?
- How can we responsibly dispose of electronic waste?

Students gather information from available sources, perform experiments and present their solutions to scientists. Candidates in the Alt Cert program work with the Sleuth teachers, helping to facilitate activities and then listening and contributing to the debriefing and evaluation of the activity.

A third type of internship is in informal education through the Jurica-Suchy Nature Museum on campus (BU, 2014)). Candidates spend time in the museum with visitors and work with the curator and education coordinator to help make new "Discovery Boxes." The Discovery Box program is a free loan program of educational kits about various natural history topics such as animals and their habitats, human cultures, and renewable energy. Each kit is aligned with the Illinois Learning Standards and includes background information, suggested classroom activities, and a variety of specimens for students to touch and examine. Many boxes also include a DVD and selected books; both fiction and nonfiction, to further engage students.

Career Awareness

One goal of the Noyce program is to recruit individuals with strong STEM backgrounds who might otherwise not have considered a career in K-12 teaching. Benedictine has a large pool of science and mathematics majors, of which less than 1% enter the teaching profession. A major push of this grant is to increase the awareness of teaching as a viable career choice. All new students in the College of Science are required to explore career opportunities using an online course structure. Students answer a series of questions about job descriptions, salaries, required training, potential for growth, etc. using a collection of links to career information. They are also required to attend a session featuring a panel of three alumni who have been recruited to answer questions about their careers. Each panel features a teacher who provides insight into the teaching profession. Response to these sessions has been very positive overall and has increased awareness of teaching as a desirable and fulfilling profession.

Because of the job outlook for teachers in STEM fields, Benedictine has limited its program to those undergraduate students and professionals who will pursue licensure in mathematics, physics and chemistry. Two of the most popular undergraduate majors at Benedictine are in the biological sciences. A challenge ahead of the institution is the redirection of biology majors to go into these areas of teaching. With the revision of state requirements for middle school and high school teaching licensure, there is opportunity for those who major in the biological sciences to tailor their coursework to address the increasing interdisciplinary nature of teaching science. The path to being considered highly qualified to teach physical science in combination with life sciences is being promoted at the middle school level. As such, Benedictine seeks to recruit majors in the biological sciences, who already are required to take 27 hours in chemistry and physics as cognates to their major, to extend their content knowledge of these physical science areas so that they can effectively teach these courses. This challenge is addressed through academic advising and individual promotion of university biology students identified by faculty as promising prospects.

Learning Assistants

A third strategy for recruitment of new STEM teacher prospects is the development of a Learning Assistant (LA) program, based on the Colorado Learning Assistant Model (Otero et al., 2010; Learning Assistance Alliance, 2014). Talented undergraduate STEM majors are hired as LA's in introductory STEM courses to promote student interaction and provide opportunities to articulate and defend their ideas. LA's receive pedagogical support through weekly content preparation with their faculty mentor and at weekly forums where pedagogical techniques are discussed and practiced.   While the intent of implementing the LA program is to increase the numbers of potential candidates interested in teaching as a career, one side benefit is that it improves the education of all science and mathematics university students, especially the mastery of the subject by the LA's themselves, through the use of more active learning pedagogies. This program also meets the objective of "engaging science faculty more in the preparation of future teachers" (Otero et al., 2010).

Restructuring Curriculum to Scaffold Inquiry and Problem-Based Learning

It is well established that teaching and learning are not synonymous (NRC, 2007). Using this premise, inquiry is promoted as a method of instruction, where constructivism of student concepts is explored as a method of learning. Scientific inquiry was defined in the National Science Educational Standards (NSES) as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world." (NSES, 1996). However, common use comes in many flavors (Abd-El-Khalick , 2004). Although both the the NSES and the NGSS emphasize inquiry in their descriptions of the kind of instruction they promote, they take care not to recommend a single approach to science teaching. As such, the NGSS promote "best teaching practices" (NGSS, 2013b). Teachers should use different strategies to develop the knowledge, understandings, and abilities described in the content standards, "Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry" (NSES, 1996).   The National Science Teachers Association (NSTA) recommends an inquiry approach to use hands-on activities that keep students minds-on.   Several of the stated objectives (NSTA, 2004) are:

- Plan an inquiry-based science program for their students by developing both short- and long-term goals that incorporate appropriate content knowledge.

- Implement approaches to teaching science that cause students to question and explore and to use those experiences to raise and answer questions about the natural world.
- The learning cycle approach is one of many effective strategies for bringing explorations and questioning into the classroom.
- Guide and facilitate learning using inquiry by selecting teaching strategies that nurture and assess student's developing understandings and abilities.
- Experience science as inquiry as a part of their teacher preparation program. Preparation should include learning how to develop questioning strategies, writing lesson plans that promote abilities and understanding of scientific inquiry, and analyzing instructional materials to determine whether they promote scientific inquiry.

With the advent of the NGSS, Benedictine's methods classes in biology, physics and chemistry teaching are being updated. More active pedagogies will be incorporated into the methods classes, promoting best practices as described in the professional standards (NGSS, 2013b). In addition, after time in the classroom, all Noyce Scholars will be required to attend an Inquiry Pedagogy workshop offered by the Science Inquiry Institute of the Golden Apple Foundation (SII, 2013). This is a professional development initiative to increase the ability of teachers to engage students in using the inquiry approach to teaching science, based on a constructionist learning method. A variety of classroom activities are used to engage participants in their own understanding of inquiry science and classroom management skills inherent to the inquiry process are introduced and modeled by the instructors through these activities. To deepen understanding of disciplinary core ideas, activities are aligned with the crosscutting concepts such as cause/effect and systems modeling, both numerically and by design. Crosscutting concepts are intended to unify the study of science and engineering through their common application across fields (NRC, 2012). All activities are designed to keep in mind the limited resources for supplies and equipment found in many schools.

Alignment of the biological sciences curriculum at Benedictine University is currently underway in keeping with the Vision and Change initiative promoted by the American Association for the Advancement of Science (AAAS), NSF, and the Howard Hughes Medical Institute (HHMI) and major biological societies (Vision and Change, 2013; PULSE, 2013). This is a competency-based approach to undergraduate biology education that focuses on demonstrating analytical, experimental, and technical skills as measurable outcomes of students learning. Biology literacy is defined primarily in terms of acquired competencies, demonstrated within the context of fundamental biology concepts (Vision and Change, 2013). One of the main features of this redesign is the promotion of active learning of these core competencies. University students will have this mode of teaching modeled for them in their classes. For example, the core competency, "ability to use quantitative reasoning," will require them to apply quantitative analysis to interpret biological data. They can do this by developing and interpreting graphs, applying statistical methods to diverse data, using mathematical modeling, and managing and analyzing large datasets.

While this initiative in undergraduate teaching is to promote increased learning and retention of content while developing advanced thinking skills, participation in more active learning at the college level is anticipated to facilitate teaching practices promoted in the NGSS. The NRC Framework (2012; NGSS, 2013b) lists best teaching practices as:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

While upper-level undergraduate STEM courses routinely reflect a subset of this list, the challenge is to move this kind of approach to the freshman and sophomore level courses. The more these teaching practices are modeled in STEM courses, the easier the implementation will be for new teachers to incorporate them into their middle school or high school classrooms.

Mentoring New Teachers

Studies have shown that a major factor in the retention of new teachers in high-need school situations is mentoring support (Ingersoll and Smith, 2004; Wang et al., 2010). All new teachers in Illinois are expected to be mentored by the department in which they are teaching. Novice teachers, whether in student teaching as undergraduates or as interns in the Alt Cert program, are provided with two mentors: the university supervisor and the dedicated grade 6-12 mentor. The university supervisor evaluates the novice teacher’s knowledge of content, effective teaching methods and classroom management performance on a regular basis. The dedicated K-12 mentors make classroom visits and work with the novice teacher to resolve issues related to specific classroom and school-related situations. This mentoring process will be extended for an additional year for all Noyce scholars in order to offer them more support and to increase retention. Benedictine university supervisors will remain available for content mentoring as needed. The K-12 mentors will continue a more active mentorship, both on an individual basis as well as promoting dialog among Noyce scholars on topics of interest or concern using social media. A Facebook page or other agreed upon venue will be set up for online interactions. It is anticipated that Noyce scholars will form a community that will provide mutual support and guidance long after formal mentoring has ended.

Research
The Noyce program also supports the study and promotion of pathways for STEM teacher education through research and development. The focus of Benedictine's research is to investigate how teachers' learning and teaching styles impact student learning when instruction is responsive to students' learning styles.

Study Design

The Differentiating Instruction through Learning and Teaching Styles (DILTS) Project, a study funded by the Noyce grant, is designed to support efforts to create a more scientifically literate population capable of meeting the national need for a competitive workforce. This struggle was starkly described in 1983 with the release of *A Nation at Risk: The Imperative for Educational Reform* (NCEE, 1983). Although significant amounts of time, resources, and effort at local, state, and national levels have been expended to develop and implement national science standards, create new teacher effectiveness assessments linked to student learning, and devise strong ongoing teacher professional development programs, science assessment scores of American students remain remarkably "average" when compared to similar-aged students internationally. Recent national and international assessments such as the National Assessment of Educational Progress (NAEP, 2013), the Program for International Student Assessment (PISA, 2012), and Trends in International Math and Science Studies (TIMSS, 2011) continue to document America's lack of significant progress in improving students' science assessment scores. In fact, a comparison of students' assessment scores in science from the 2011 TIMSS report to previous reports shows that scores have had no detectable change for more than two decades. (TIMSS, 2011)

In an effort to improve student learning, differentiation of instruction has become a significant element when planning lessons for the classroom. It is primarily used to address the unique needs of special education students, English language learners and other students with identified conditions. Rarely has differentiation of instruction been focused on the learning needs of "normal" students. Yet, a significant body of research documents that when instructional pedagogy matches student learning style, there is an increase in academic achievement and improved attitude toward learning.

The DILTS Project is designed to explore the impact of teachers' learning and teaching styles on students' learning when instruction is differentiated to meet students' learning styles. The targeted populations for this proposed study are comprised of:

- Secondary high school students in high need school districts taught by
- High school science teachers located in high need districts and who are program completers of Benedictine University's bachelor's program in secondary science teacher preparation or its post-baccalaureate alternative certification program in science education.

Both of the programs identified above prepare candidates to use the Next Generation Science Standards (NGSS) when planning curriculum and to use a wide variety of pedagogies, including inquiry and problem-based learning, for instruction.

This study will take place in two phases. The first phase will identify program completers who use inquiry and problem-based learning strategies in their classrooms. Once these teachers have been identified, the second phase of the study will begin. This phase will identify the learning and teaching styles of teachers and the learning styles of their students. Data will be collected about pedagogies used and the rationales for their use. Analysis of data will address the impact of teachers' learning and teaching styles on student learning when instruction is responsive to students' learning styles. Once the study is completed, its results will be shared with the professional community. More importantly, these results will have significant impact on the design of Benedictine's secondary science teacher education program and the alt cert program. For example, if the data from DILTS reveal that Benedictine's program completers typically rely on teacher-centered pedagogies rather than the inquiry and other student-centered pedagogies that are stressed in Benedictine programs, then courses in pedagogy, curricular design, classroom management, and educational psychology will be revised to create stronger connections between the psychology of learning with methodologies of teaching and their effectiveness in supporting long-term student thinking and learning. These stronger connections will be scaffolded with increased opportunities to practice skills in classrooms with the support of effective teachers. The final result from the use of DILTS' data should be stronger teacher preparation programs in the sciences and higher student learning in these content areas.

Conclusion

Today's world is heavily and increasingly reliant on advances in science to create a stronger society and healthier environment. To sustain advancement, society itself must become more scientifically literate. The need for such literacy presents a significant challenge to all educational institutions and their ability to provide strong science foundations for their students that can be used productively.

Benedictine University has accepted this challenge. It has created science programs with strong national reputations and secured a Noyce grant to support STEM initiatives. These STEM initiatives are focused on three areas:

- recruitment of talented people into science teacher licensure programs that prepare them to be effective teachers capable of inspiring their students to become scientifically knowledgeable and curious;
- research that investigates the impact of teachers' learning and teaching styles on students' learning when instruction is differentiated to meet students' learning styles; and
- research to continuously improve the STEM teacher preparation programs.

Benedictine's story about its STEM initiatives is not yet done. The outline is in place, resources available, and commitments made. The evolution of these initiatives will lead to the next generation of high quality programs and support for effective STEM teachers who are committed to students in high-need schools.

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Start at the beginning: Unpacking experience to gain insight on how to teach science

by Rebecca Clemente, Ph.D.

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Abstract

I have taught a science methods course for nearly a decade. As teacher educators are well aware, teacher candidates come to these classes with varying knowledge, skills, and dispositions. At the beginning of the term[1] it is important for me to discover these so that I have a better snapshot of who my students are. This article focuses on one assignment, the Science Autobiography, in an undergraduate course I teach titled, EDN 326 Elementary Teaching II. Its catalog description states, Development of teaching methods including instructional and assessment strategies where K-12 students engage in learning experiences that improve their abilities to apply knowledge that will develop their abilities to analyze, evaluate, and create. Emphasis on differentiated instruction, indirect teaching methods, and teaching and assessment strategies that facilitate higher-level learning. (North Central College, 2014-2015, p. 108)

What is not evident from the catalog description is that the focus of the course is teaching science[2]. The intent of the course is to use topics in 1–6 science[3] and those related to instruction (e.g., inquiry, differentiation) as a means for teacher candidates to experience and apply them.

Student Science Autobiography

Abell, Appleton, and Hanuscin (2010) remind us that "learners come into a learning situation bringing with them their preexisting ideas, skills, and feelings that are organized in the mind as sets of clusters of ideas and experiences" (p.25). Teacher candidates have ideas about subject matter, teaching, teachers, and student learning that is expressed, repressed, and nearly forgotten, that influence them as they navigate their way through a teacher education program (Bransford, Derry, Berliner, Hammerness, & Beckett, 2005; Chessen & Shaw, n.d.; McCulloch, DeCuir-Gunby, Marshal, & Caldwell, 2013; Portalupi, 1995).

In order to tap into past experiences as a learner and to explore teachers' practices that color and shape those experiences, my students write an autobiography of their science experiences (see Appendix for the 2014 assignment details) by the second week of the term. My overall intent is three-fold. First, I want them to think more broadly about science, science teaching, and how their attitudes

[1] Our terms are ten-weeks long

[2] This is the second year of our new teacher preparation curriculum to meet the new State Standards. Instead of calling this a science methods course it is a methods course that uses science teaching as the tool through which methods are learned.

[3] Currently focused on Illinois K-12 Learning standards. The State will be transitioning to NGSS and expects teachers to use these starting in the 2016-2017 academic year (see http://isbe.net/ngss/default.htm)

about science teaching have been molded. Second, I revisit themes that emerge from the autobiographies throughout the course as a means of illustrating that learning to teach unfolds, is not a fixed state, e.g., you are a natural teacher (Dweck, 2006), and there are many effective teaching strategies even if my students have not experienced them[4]. Lastly, the autobiography gives me a glimpse of how my students view curriculum. I use these to expand their understanding of the standards and the internal and external pressures that shape teacher decisions as they determine what and how to teach. The science autobiography is an invitation to become more aware, armed with understanding and, hopefully, become more receptive to other ways to teach.

My students' introductions to their autobiographies set the tone for what is to come:
"I'm not sure where to even begin. I have a terrible memory and most of my childhood is a blur to me. My dad is a doctor and has always tried to push science on my sister and me….He loves science very much. I on the other hand hated science" (E.M.).

"What I remember about my science education growing up is limited as it was many, many years ago and the way that it was taught was less than memorable" (C. K.).

"What does science mean to me? Well, to answer that question it means a whole world-wide of experiments, great teachers, and peer pressure" (A. B.).

"Science growing up was a love hate relationship with me. Before I started going to school my mom would always do fun little science projects with us….when I was about four my mom let me play with dish soap and a straw" (D. V.).

These are some of the voices of my students as they prepare to discuss their experiences with science and science teaching and learning. This is the longest section of the assignment. It is designed so that my students discuss their in and out of school science experiences. To "prime the pump" I often ask students to think about their earliest experience with science and to talk with a shoulder partner. As we share a few of these (and I share mine as well, e.g., an encounter with a skull that my physician father had from medical school and, of course, appropriately found in the attic) it helps them recollect more experiences. They are also reminded to call home and talk to a parent or guardian about their early years. What they have to say can be poignant and is representative of the curriculum being taught and reveals teaching strategies, teacher attitudes, and the current pressures that shape these:
"My earliest memory of science would have to be in first grade when we grew plants. Let me just start off by saying that this activity was the start of my hate for science" (E. M.).

"I was looking forward to fifth grade since I was in second grade. [Fifth grade] was the year of the famous potato experiment. Instead we all had to do so many practice tests for the standardized test we needed to take that year. So all year the only science we had was reading different articles for reading and writing practice. It was not fun" (D. V.).

[4] Those who facilitate teacher candidate learning know how difficult this can be. See Hammerness, Darling-Hammond, Bransford, Berliner, Cochran-Smith, McDonald, & Zeichner, 2005.

“My most memorable experience with science was during my junior year of high school. I took Weather and Environment. This class provided a lot of hands-on experience. We had a field trip and a lab down on the Riverwalk. We were in groups that went out on the paddle boats to collect information on the depth of the water. Later we used this information to create a geographic map showing the contour lines for the depth of the lake. We also collected algae and other specimens that we examined under a microscope. This was memorable because it was an actual experience in the field” (S. B.).

“We created ‘Elephant Toothpaste.” Hydrogen peroxide, dish soap, and yeast as a catalyst were used for this experiment…None of us expected the reaction that took place. . . It also helped to have a teacher that was so passionate about science” (E. M.).

The autobiography culminates with an analysis of the evidence from their past to discern a pattern of when science was positive and when it was negative. Typically the negative experiences represent learning as reading, note taking, answering questions, taking tests, poor teacher attitude, or made incomprehensible because explanations were too complex or inadequate, or students were blamed for their inability to learn:
“The direct teaching methods that most of my science classes have been comprised of have left me cold and uninterested in science” (C. K.).

“The classes that were by the textbook were not memorable at all. These provided very little experimentation or inquiry” (S. B.).

“It’s very important as an educator to be interested and excited to teach the topics. If you aren’t interested, what makes you think that your students are going to be interested” (E. M.)?

Students characterize science study as positive when it is hands-on, relevant, experiential, and facilitated by knowledgeable passionate teachers:
“Positive experiences that I had were due to my teachers being so passionate about the subject and wanting us to succeed no matter how many times they had to explain something to us” (E. M.).

“I truly believe that the positive science experiences [occur] when the teacher is passionate about the subject and involves the students in the lesson” (C. K.). “

Most of my positive experiences have been when I was younger because there were no social barriers to view science as nerdy or hard-work. . . . Students could create something so intrinsic and creative that it made science seem interesting and rewarding” (A. B.).

Most heartening is that the collective experiences of my students show that there are passionate engaging teachers who design interesting units and experiences.

As one might suspect some of my students are turned off by science by the time they reach middle school (“I felt like I was endlessly doing science homework and worksheets in class.” A. B.) and others are ignited by a college class (I took SCI 109. . . [it] turned everything around for me.” E. M.). My students come to understand that to teach science (and truly any subject area) one needs to be enthusiastic ("Teachers should be excited and ready to teach each topic." E. M.), student-centered ("This means coming up with experiments that will interest them, engage them and ultimately teach them." C. K.), creative (raising a butterfly and a baby chick were visual and allowed me to be involved in science." S. B.), and unafraid to teach using a range of teaching strategies ("Give students multiple options for learning science: through packets of information, science experiments, videos, and using websites to explore the world of science." F. C.).

Since this assignment comes at the start of the term, I look for opportunities to refer back to the themes that have emerged and use them to support other experiences in the course. For example, the majority of my students have never engaged in a long-term inquiry. At the end of week one I launch either a five-week moon journal or mealworm journal experience.[5] I encourage them to seek as many opportunities as possible to teach science during their field experience (i.e., fifty hours shared with the Literacy II course[6]) or to explore whether their cooperating teacher would be open to an integrated lesson. Many of my students primarily experience traditional teaching in their field experience and a narrow curriculum due to today's emphasis on reading and mathematics which often reinforces the negative experiences they have had. To counterbalance these I incorporate a range of indirect teaching methods into the course such as a jigsaw on differentiated learning, a 5-E cycle exp loring electrical circuits, or applications of science process skills through a biodiversity experience or solar system experience. I seek out video examples of best practices for us to critique and use to illustrate course concepts.[7] Ultimately, by the end of our ten-week term I hope that many of my students embody what one of my students concluded in the summary of her science autobiography:
I never really pictured myself as someone who liked science but when I look at all the positive and negative experiences I have had with science, the positives outweigh the negative. . . It is interesting how science today is about encouraging inquiry. . . .Science may have seemed like a little part of me, but now it is something that I look forward to learning more about each day from my own experience and from my future students. All I know is that science is an on-going, interesting, and enthusiastic process. (A. B.)

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[5] See Abell, Appleton, & Hanuscin, 2010, for ways to capitalize and embed a range of experiences into methods courses. You will find some resources here as well. Deborah l. Hanuscin, http://web.missouri.edu/~hanuscind/

[6] Teacher candidates are required to teach two science lessons. This has become difficult to do over the past several years with the emphasis on reading and mathematics. They may teach other subject areas as long as it isn't something they taught for their Literacy II requirements. Cooperating teachers and NCC supervisors sign-off on this.

[7] The Teaching Channel (https://www.teachingchannel.org/), Edutopia (http://www.edutopia.org/), Success at the Core (http://successatthecore.com/teacher-development/Default.aspx), Annenberg Learning (http://learner.org/), Teacher Tube (http://www.teachertube.com/)

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Appendix

Science Autobiography

As you develop your teaching knowledge and skills, it is important consider the experiences you have had throughout your educational experience. Often we do not know why we feel positive about some things and negative about others. For this assignment the focus is on learning science. This assignment is designed to help you discover some of what has shaped your feelings about science and learning science. The ideas generated will be used to gain insight on what teaching strategies and teaching attitudes are best to promote student learning. The ultimate aim is for you to make discoveries from your past experiences that will help you become the teacher you wish to be, one who makes a difference in a student's life. A former EDN 326 student stated, "I hope that one day I will be able to teach my students science and that they will love it and walk away from each lesson with more knowledge and interest than they walked in with to the lesson" (E. M. with permission).

Getting Started:

Think about the science experiences you have in and out of a school setting. Don't worry if you do not remember everything…our minds just do not work that way. Do consider experiences you think were positive as well as the one you think were negative. Present your autobiographical narrative as fairly as you can.

Relate early memories of school science and your reactions. Write about your experiences with science and with school science up to now.

The following questions can help you think through your science experiences:

1. How did your family take an interest in science? (Call home if you need to…especially for those early years.)

2. When you look back at your science education, what do you see?

3. How much science did you study in school (include college)? (Was science daily? Several times a week? Every other five-week period?)

4. When did you like science? When did you dislike science? (What topics captured your interest? Which did not?)

5. What were your teachers like? In what ways did some teachers help you learn or not help you learn?

6. In examining your story, when has science been a positive experience, a negative experience?

7. What personal experiences with school science, scientists, science in the media, and science teachers stand out for you?

8. What could/should a teacher do to help students learn science?

Clip art: http://school.discoveryeducation.com/clipart/clip/thinkingcapwhoa.html

Format of your autobiography.

It should have these sections *(please use headings for each section):*

Introduction (write this last…it should provide a brief overview of what you will address in your autobiography)

My science education (earliest memories to today - yes, birth to now – address each year of school) - Mention both positive and negative experiences in this section (provide specific examples of experiences and describe your teachers – feel free to use initials or pseudonyms and the teaching strategies they used). This will be the longest section of your paper. Save your most memorable experience for the next section.

Most memorable experience (State why this was the most memorable and provide details and examples about the experience and describe your teachers and the teaching strategies they used.)

Looking at my experiences (Look at the experiences you wrote for *My Science Education* and *Most Memorable Experience*, critique why some of your experiences have been positive and some negative.) State the common set of conditions that made something positive or negative and discuss these.

Teaching science (Given what you have re-examined about your science experiences/education, state ways in which teachers should help students learn science. Feel free to tap into things you learned in Teaching I that are applicable to science teaching. What is one science teaching goal you have for yourself that you might start on during the term? What is one thing you can do this term to begin working on this goal?)

Summary (state what you have discovered or reaffirmed about yourself and your experiences with science.)

Use 1" margins all around, 11 or 12 point font, and double space the paper. Read through the assignment rubric for other details. Based on past terms, papers that are more than five pages long tend to provide teacher candidates with sufficient details and evidence from the past in order to analyze these and support the writing of "Looking at my experiences" and "Teaching science" sections. (Some of the strongest science autobiographies are 10-12 pages long. – remember to provide details and let your autobiography flow.)

Evaluation of Science Autobiography

Name ____

Score ________/______

autobiography is detailed and in depth (provides thorough examples), examples are elaborated, all topics addressed	5	3	1/0	autobiography lacks detail and depth, examples are in the form of general statements, topics missing
reflection is evident - states (a) what has been learned by looking at the past, (b) how this may effect them as a teacher of science, (c) what new perspectives have been gained		3	1/0	(a) list of events and experiences with little or no reflection or critique (b) reflection made in absence of details and critique of past experiences
states one goal to begin working on during the term that is doable. Action step is a suitable first effort toward achieving the goal.		2	1/0	Goal cannot realistically begin during this term. Action step too broad.
used headings to show sections of the autobiography			1/0	few or no headings used.
used electronic page numbering			1/0	lacks electronic page numbers
proofread for spelling			1/0	not proofread for spelling
proofread for grammar, syntax			1/0	not proofread for grammar, syntax
proofread for mechanics			1/0	not proofread for mechanics
title page and stapled		2	1/0	

IMSA© FUSION: Preparing Students for Future Scientific Expertise
by Michelle Kolar, Dora Phillips, Liz Martinez, and Laurie Sutherland

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Abstract
Illinois adopted the Next Generation Science Standards (NGSS) on February 19, 2014 with implementation scheduled to begin in the 2016-17 school year. This article explores (1) the national and statewide need for STEM college and career readiness based on current data; (2) the research on best practices in STEM teaching and learning; and (3) the work of the Illinois Mathematics and Science Academy (IMSA) to create IMSA Fusion, a science, technology, engineering and mathematics (STEM) educational program that is aligned with NGSS and utilizes research-based best practices to serve Illinois educators and students.

The introduction of the Next Generation Science Standards, following closely on the heels of the Common Core State Standards, provides an opportunity for a national discussion on STEM (science, technology, engineering and mathematics) readiness in America. Dixon and Moon suggest what is at stake: "To maintain a healthy society capable of either collaboration or competition with international counterparts, the U.S. must continue to prepare students who are capable of becoming experts in science." (2014, p. 334) Although the implementation of Common Core State Standards across the country focused our attention on national standards in education, many have felt that the conversations regarding science education have lagged behind those in mathematics and English.

National Educational Trends
According to the U.S. Department of Commerce Economics and Statistics Administration (2011), STEM fields will become our largest area for future employment and will necessitate a workforce that is literate in science, technology, engineering and mathematics, "STEM occupations are projected to grow by 17.0 percent from 2008 to 2018, compared to 9.8 percent growth for non-STEM occupations…STEM workers command higher wages, earning 26 percent more than their non-STEM counterparts." It is unfortunate that although the national unemployment rate is still roughly 6% there are an estimated four million unfilled jobs in STEM fields because of a lack of adequately trained workers. Not coincidentally, the U.S. ranks 47th out of 144 countries in mathematics and science (Harlan, 2014). If the United States is to be a global economic presence our students must graduate from high school as not only college ready, but STEM ready as described in the Next Generation Science Standards (Achieve, Inc., 2014): "The nation's capacity to innovate for economic growth, and the ability of American workers to thrive in the global economy depend on a broad foundation of math and science learning, as do our hopes for preserving a vibrant democracy and the promise of social mobility for young people that lie at the heart of the American dream." (Carnegie).

The demonstrated need for an increased STEM workforce requires that the American education system must graduate students who are STEM proficient. In order to complete this task, educators must first evaluate the capacity of high school graduates to successfully complete post-secondary STEM programs. In other words, America needs to closely examine STEM readiness.

In recent years a significant educational emphasis has been placed on graduating high school students who are "college ready" as defined by ACT scores. Each year ACT issues its *The Condition of College & Career Readiness* report which includes benchmark scores that correlate with readiness to enter a 100 level college course with a 75% chance of scoring a "C" or higher (ACT, Inc. 2014). The measurements for this definition of college readiness generally discussed are an English score of 18 and a math score of 22. However, also included in these annual reports are a science score of 23 and a reading score of

21, indicating preparation to successfully complete introductory laboratory science and social science courses. In *The Condition of College and Career Readiness National* (2014) ACT, Inc. indicates that currently 26% of students nationwide leave high school ready for college in all 4 areas; sadly, 31% leave high school meeting none of the four benchmark scores. Thus, more students leave American high schools unready for any college core course than leave ready in all four subject areas. English and reading scores are highest with 64% and 44% of students prepared, respectively. Science scores lowest with just 37% readiness to math's 43% (ACT, Inc. 2014). Clearly, American students do not leave high school STEM ready.

Illinois Educational Trends

In Illinois, 100% of students complete the ACT exam, as a mandated part of school-based standardized testing, allowing this to be a strong data point for educational analysis (ACT, Inc. 2014). Illinois students score just below the national averages with 62% English, 41% reading, 41% math, and 35% science readiness scores. Currently, only 26% of high school graduates in Illinois are ready for all subjects, in contrast with the 81% of students who aspired to a postsecondary education. When scores are filtered for students indicating an interest in a STEM major, Illinois student readiness rates increase to 72% English, 50% reading, 53% math, and 46% science with 36% ready in all four subjects. Students interested in future STEM study and careers select different courses and prepare differently for the future than their classmates.

In Illinois, English/Language Arts is taught in double blocks of study throughout many elementary and junior high schools and is required for all 4 years of high school. Given that amount of emphasis and preparation, it is not surprising that English leads the college readiness content areas as reported by ACT with 62% (2014) of Illinois students reaching the college ready benchmark. Conversely, elementary schools often minimalize science as ELA and other subjects take priority forcing science to relinquish minutes from its allotted time block. Many elementary schools are even forced to rotate between science and social studies cutting down instructional time even further. Similarly, junior high school and/or middle school science courses provide no laboratory time and thereby leave these students without hands-on science learning opportunities.

Illinois graduation requirements for math and science increased only recently, but still fall below the levels recommended by college admission departments. The science requirement increased from one year to two years for students entering high school in 2007, but does not require a lab component (ISBE). It should not be surprising given the time and lack of emphasis on science education that only 35% of ACT test takers are considered college ready in science. Although Illinois recently increased the math requirement to 3 years, Algebra II is not required as part of this increase (ISBE). The Southern Regional Education Board (n.d.) indicates that both ACT and High Schools That Work recommend Algebra II and 3 years of lab-based science as minimum requirements for a rigorous high school education. Four years of math and 3 years of lab science are recommended by most colleges for admission. Also lacking from required Illinois curricula are computer science or technology education requirements. According to MacNeill (2014), "the best way to prep for an undergraduate degree in computer science is to cultivate knowledge and skills in mathematics and laboratory science." An argument can be made for increasing both the type and rigor of coursework required for graduation in mathematics, laboratory science, and computer science if Illinois students are to leave high school STEM ready.

Rapid Change

Over the past twenty years technology has reorganized how we live, how we communicate and how we learn—and educational leaders have embraced the idea that science is pertinent in all aspects of life; classroom educators have grasped how differentiated instruction and how various students process information; and we have become keenly aware how today's students have access to more information than those of previous generations. Simply put, knowledge is no longer contained in dusty encyclopedias or confined to the brains of the erudite.

Gonzalez (2004) explained, "One of the most persuasive factors is the shrinking half-life of knowledge. The 'half-life of knowledge' is the time span from when knowledge is gained to when it becomes obsolete. Half of what is known today was not known 10 years ago. The amount of knowledge in the world has doubled in the past 10 years and is doubling every 18 months." As a result, education must change both in methods of delivery of content and in cultivating skills in learners that will allow them to keep pace with a world that is constantly changing.

P21 Framework

The Partnership for 21st Century Skills (2009) was formed for the purposes of bringing together the business community, education leaders and policymakers to create a comprehensive set of skills that, along with content mastery, are what all sectors can agree are needed for student success. The P21 Framework (*Partnership*, 2009) "describes the skills, knowledge and expertise students must master to succeed in work and life; it is a blend of content knowledge, specific skills, expertise and literacies." P21 divides student outcomes into four areas:

1. Core subjects and 21st Century themes.
2. Life and career skills.
3. Learning and innovation skills.
4. Information, media and technology skills.

   The research and recommendations from the Partnership for 21st Century Skills strongly indicate that students need more than general content knowledge to succeed in today's global economy.

It is unlikely that the mandated increase of instructional hours for STEM content will occur in the near future. However, awareness that there is a need to exceed standard and transcend traditional grade level topics and concepts is currently at the forefront of education as evidenced by the ACT reports and the P21 Framework. The need for students who are STEM ready exacerbates the need for the introduction of a national set of science standards utilizing best practices for science education. According to *Assessing the Role of K-12 Academic Standards in States* (2015), the National Research Council claims that American students are educated under 51 different sets of state standards (50 states and District of Columbia). States predominately use either the National Science Education Standards from the National Research Council (NRC) established in 1996 and/or Benchmarks for Science Literacy from the American Association for the Advancement of Science (AAAS) published in

1993 as the basis for these differing standards. Both sets of standards are now more than 15 years old providing an opportunity for an updated and unified look at science standards in America.

Next Generation Science Standards for Today's Students and Tomorrow's Workforce

In order to address the need for well-prepared STEM students, Achieve, Inc designed the Next Generation Science Standards (NGSS) reflecting findings from the National Research Council with input from the National Science Teachers Association and the American Association for the Advancement of Science and with support from the Carnegie Corporation of New York (2013). These standards are based on research regarding both the nature of science and how students learn about science coupled with changes in the availability of knowledge and extensive research into 21st Century Skills necessary for success in the current and future world. The NGSS is designed to promote richness in both content and practice. In addition, the standards are coherent across disciplines and grade levels. These standards offer students an internationally benchmarked science education which will prepare them for college and introduce them to the wide world of STEM.

Literature Review

The need for a change in science education is evident. The solutions, such as NGSS and others, that are being put forth nationally and at the state level align with the educational research about best practice science teaching and learning, student motivation and best practices for teacher development.

Best Practices in Teaching and Learning

Using inquiry based methods to engage and teach science to students is grounded in educational theory as well as is "congruent with how we think people learn." (Capps & Crawford, 2013) "Inquiry based instruction resembles scientific inquiry by engaging students in instruction that parallels the work of scientists." (Capps & Crawford, 2013) Inquiry based teaching looks different than traditional teaching; it can look messy and take more time then direct methods. In the inquiry classroom the teacher role is a facilitator, helping guide students as they engage in the learning process (Anderson, 2002). The students in an inquiry based classroom are processing information, interpreting data, collaborating with others and sharing their interpretations anideas that are based on their own experiences (Anderson, 2002).

Student Engagement and Motivation

In an inquiry based classroom, students gain more ownership over their own learning, they become more engaged and intrinsically motivated to learn. Motivation is a driving factor in student engagement. Often we look at external factors to motivate students, such as grades or awards. However, we know that when students are intrinsically motivated they gain better understanding and make better connections (Herman, 2012). Daniels articulated that motivation in school can be fostered in a learning environment where students have 1) autonomy or some control over their own learning process, 2) relatedness to the content, where the learning links to real world connections, and 3) competences, when faced with rigor students have the confidence and ability to do the work (2010). All three of these factors are hallmarks of inquiry based teaching.

As students find their own motivation in an inquiry based classroom the their attitudes will change. Research by Sinatra & Pintrich demonstrates that student motivation can be a key driver in student academic success and their ability to make connections between content and experience (2003). Creating a learning experience that the students can be active and engaged in also promotes motivation (Wigfield & Eccles, 2002).

A key feature in inquiry based teaching is that it is active. Students learn best in certain classroom conditions; these conditions are active environments where students are not passive learners, but generators of information. Active learning produces results in student achievement. Through longitudinal study one sees that students who had the opportunity to perform their own science experiments, instead of reading about them or watching demonstration, learned more (Burkam, Lee, & Smerdon, 1997). Nadleson et al, articulated the need for students to also have authentic learning experiences that are grounded in inquiry (2013). Authentic inquiry based learning takes more time then traditional teaching, as students grapple with ideas collaboratively and generate potential solutions. Knowing that it takes more time, it is of concern that in most elementary classrooms time for science is actually declining (McMurrer, 2008). Understanding the factors in this decline is imperative to change the trajectory of science engagement at the elementary school level (Nadelson et al, 2013)

Teacher Preparation and Development

Ensuring that students have access to the types of learning they need to meet the standards of NGSS is key. Most teachers are not prepared with the tools to teach in this way and most school structures are not conducive to non-traditional teaching methods. NGSS is best met with inquiry-based instruction which is "a complex mixture of skills, knowledge, and creativity and can be challenging to implement" (Nadelson et al, 2013). Teachers as facilitators of learning have to manage the diversity of student paths as they may vary in their learning processes. Science inquiry requires "scaffolding students in framing questions, grappling with data, creating explanations, and critiquing explanations....prospective teachers need to understand and practice these strategies, before they can feel an honest confidence in their ability to carry out this kind of reform based instruction." (Crawford, 2007) Teacher professional development needs to have components that mimic these practices and promote growth in the teacher. As learners, teachers need time to understand their content and practice in order to hone their craft. In addition, they need support and resources as they go through this learning process. The ability for a teacher to teach science is grounded in their understanding of the content as well as their personal beliefs about science (Crawford, 2007). Development of teachers, both in-service and pre-service, will need to change to allow for new ideas and innovations in the classroom. Teachers of NGSS and inquiry need to be prepared or professionally developed to create those conditions where students can explore. IMSA suggests that schools model practices of other specialized STEM schools as a means of developing teacher expertise in these inquiry based methods (Kolar & Sondel, 2010)

IMSA Fusion Program

The Illinois Mathematics and Science Academy (IMSA) was established by the Illinois General Assembly in 1985 to "provide excellence in mathematics and science education" (105 ILCS 305). Nobel Laureate Dr. Leon M. Lederman and Governor James R. Thompson led the effort to create the institution. IMSA houses a top selective enrollment residential high school serving Illinois students and a field services team formed to "stimulate further excellence for all Illinois schools in mathematics and science"

(105 ILCS 305). Over the past 28 years, IMSA as a teaching and learning laboratory has gathered evidence of the conditions that promote STEM learning. IMSA combined this information with external research on habits and practices yielding two main findings, echoed years later by the National Research Council (2007):

1. Students learn science by actively engaging in the practices of science.
2. A range of instructional approaches is necessary as part of a full development of science proficiency.

   Such reports by the National Research Council informed IMSA's program design for elementary and junior high students to become better prepared for rigorous secondary STEM coursework.

With the support of the Illinois General Assembly, IMSA Fusion was created in 2000 to address the need for a rigorous hands-on, minds-on program for pre-secondary students. It began with 7 off-campus sites and has grown to 165 programs in 110 partner schools throughout Illinois. It is recognized among the top programs in the nation by Change the Equation, a corporate-led initiative, to identify and expand effective STEM teaching and learning to best prepare for a powerful and diverse STEM pipeline for the global future. It is also recognized as one of the top K-12 STEM programs in America by the Bayer Corporation.

Illinois schools in under-resourced communities are identified as potential "Fusion school partners." These communities are rural and urban and have large populations of low income families and in some cases tend to have large numbers of minority students who are historically underrepresented in STEM fields or are rural schools with little access to STEM activities. IMSA Fusion provides access for these students to quality STEM enrichment.

Teacher Professional Development

The school-based enrichment program is offered either as an after school program or as an embedded program during the school day. These two models allow schools to adopt the program implementation to best suit their school's needs, for example a school may offer it to students in grades 4-8 in single or multi-grade groups. Each program selects two teachers who each receive 40 hours of professional development from IMSA Fusion teacher professional developers; that is, 40 hours of STEM professional development per school year per teacher -with additional support that ensures each teacher can develop as an IMSA Fusion facilitator. This includes pedagogical training that focuses on facilitating inquiry-based, student-centered activities that create conditions for students to grapple with real world problems.

Each educator is also immersed in two different curricula areas annually that extend beyond traditional classroom content. By providing teachers with designed activities and a kit containing all of the materials they need to facilitate learning with their students, IMSA Fusion creates the conditions for these educators to guide students through these content-deep, rigorous and fun hands-on STEM learning opportunities.

Additionally, the goals for Fusion teacher professional development include the enhancement of the knowledge and skills of current educators in science, mathematics and technology. Teachers gain valuable content and pedagogical knowledge as they practice the skills developed during professional development sessions while teaching the activities specifically designed to advance these skills to their students. Included are:

1. Writing reflections about their own teaching and their students learning throughout the year.
2. IMSA Fusion team members observing every participating teacher as they facilitate lessons providing concrete feedback for continued improvement.
3. Administrators observing teachers in their traditional classrooms and providing insight about the changes they recognize occurring because of the Fusion training.

The 2013-14 IMSA Fusion evaluation was conducted by the Center for Evaluation & Education Policy (CEEP) at Indiana University and reported impressive results: over 90% of IMSA Fusion principals felt that this IMSA program enhanced their teachers' regular classroom instruction.

Curriculum

IMSA develops the STEM enrichment curriculum for Fusion specifically to address two central findings: 1) curricular topics are experiential and 2) they are delivered through a range of instructional approaches. All learning experiences are driven by the four attributes of IMSA's Core Competency: competency-driven, inquiry-based, problem-centered, and integrative. These attributes serve as design principles for the development, implementation and assessment of all IMSA curricula. As this curriculum is presented in Illinois public schools, it is aligned to the appropriate standards, currently Common Core State Standards (CCSS) and NGSS. While exploring STEM content, students learn to be innovative and entrepreneurial by using 21st Century Skills, such as collaboration, critical thinking, communication and problem-solving. Students work in groups to explore solutions to problems by using creative, analytical and critical thinking skills.

Student Engagement

Another valuable curricular feature is the highly integrative nature of the Fusion program. Unlike the typical science class, students work across disciplines in each activity. Students examine the history of a concept, conduct the experiment, graph the result and communicate the discovery. In each curricular unit, students work through the engineering design cycle and are intentionally taught that failure and frustration are ingredients in the formula for success. It is vital that student activities mirror real world experiences integrating multiple areas of knowledge and skills, allowing students to advance evaluation and modification skills as they work through iterations of various projects.

IMSA Fusion goes beyond the classroom content by providing students the opportunity for hands-on, minds-on learning in real-world STEM fields in Illinois. We need to develop these students if we are to support and sustain Illinois' STEM workforce. In response, STEM career fields are researched in order to extrapolate interesting areas of study that will teach math and science practice standards andem allow students to develop habits of mind, which ultimately allow them to learn various contents in richer, more meaningful ways. Fusion exposes students who are interested and motivated in STEM to the large variety of careers available within various STEM fields, introducing them to interesting options and identifying pathways for study through secondary and postsecondary schooling.

Lessons Learned and NGSS

Over the past 15 years, the implementation and evaluation of the IMSA Fusion program has provided lessons that support the need for and success of science standards epitomized by the Next Generation Science Standards. Expanding on the original two Fusion best practices—1) curricula topics are experiential and 2) delivered through a range of instructional approaches—Fusion has evolved and embedded four foundational attributes throughout the program that enable student STEM success. All students need:

1. To understand and use scientific explanations.
2. To conduct experiments and gather evidence.
3. Time to struggle, reflect and connect lessons learned with teachers facilitating learning through varied instructional strategies.
4. To share science.

NGSS is organized into three dimensions: 1) practices, 2) crosscutting concepts and 3) disciplinary core ideas. For the purpose of this article, we focused our alignment between the four foundational Fusion beliefs and the NGSS practices dimension. Next we illustrate these connections by sharing one activity created as part of our Synthetic Biology curriculum (see Case Study I).

IMSA collaborated with the BioBuilder Education Foundation team of scientists and educators from MIT to identify appropriate content and practices for 4th and 5th grade students. Using this information, IMSA developed a curriculum that exemplifies our four attributes and aligns to the eight practices of NGSS.

Fusion Belief 1. <u>Students need to understand and use scientific explanations</u>. This is not the memorization of facts, but is an understanding developed as students increase awareness of the way the world around them works through a scientific filter. Often younger students are given incomplete or incorrect information to answer their questions instead of being encouraged to investigate answers. IMSA Fusion introduces scientific content through inquiry-based teaching methods.

Case Study: Synthetic Biology Belief 1

Students need to understand and use scientific explanations.

In our Synthetic Biology example activity, 4th and 5th graders pop microwave popcorn recording observations at various intervals. They are then able to graph it and begin the analysis and interpretation processes. Next, students are introduced to the scientific explanations for phases of cell growth: lag, log and stationery. Actual cell growth data is given to students to compare to their data so they may look for any patterns. Throughout this entire time, students are encouraged to and taught how to ask questions: What occurred? Why did the pattern emerge? Will it remain unchanged?

Students take this knowledge regarding cell growth and transfer it to baker's yeast. They are responsible for engineering optimal growth given the materials available, identifying problems and adjusting procedures as they progress. Throughout this activity, students utilize NGSS practice number one: asking questions (science) and defining problems (engineering**)**. In order to be able to transfer knowledge and practice from one concept to another, students must learn the history of science and demonstrate proficiency with the principal laws, theories, and models of science. However, we believe that students learn deeper and can connect concepts more successfully when they construct their own meaning as part of the process.

Fusion Belief 2. Students need to conduct experiments and gather evidence**.** This belief encompasses NGSS practices two through five:

1. Developing and using models.
2. Planning and carrying out investigations.
3. Analyzing and interpreting data.
4. Using mathematics and computational thinking.

The importance of experiential learning for science cannot be emphasized enough. Watching demonstrations and videos and reading about previous experiments are not sufficient. Evidence is the foundation of STEM disciplines. The National Science Teachers Association (2004) declared, "In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions." Building proficiency requires that students learn to generate and evaluate evidence in order to create and refine models and experiments. Students need guidance as they learn to narrow questions, decide what to measure to support the inquiry, and to design processes to collect appropriate measurements. They need to master mathematical and computational tools and systems as they collect and analyze data.

Case Study: Synthetic Biology Belief 2

Students need to conduct experiments and gather evidence.

Students in the 4th and 5th grades who experience the Synthetic Biology curriculum will collect, graph, analyze and interpret data on popcorn popping to find that it represents the lag, log, and stationary phases of growth of many microorganisms. They will then use this model to develop and test a protocol to study the growth of baker's yeast. Finally, they will have an opportunity to compare the data from the two different experiments. Both activities are economical and accessible, yet the process and results will lay the foundation for connecting to other concepts within the curriculum. These other ideas include proteins, programming, parts and standardization, lab techniques, and application of synthetic biology.

Fusion Belief 3. <u>Students need time to struggle, reflect, and connect lessons learned with teachers facilitating learning through varied instructional strategies</u>. Science learning is deep and builds upon other concepts—failures and successes. We believe that students need to be able to fail in order to learn. Completing only the successful experiments of others will not provide as deep of a learning experience as students will experience as they struggle to construct explanations and design solutions (NGSS practice 6). Most STEM advancements arose over time from multiple experiments that did not work, trying to explain why things did not work, and as a combination of input from multiple fields. In fast-paced classrooms with so many concepts to "cover," depth of learning can be sacrificed to speed of learning. Teachers need to facilitate lessons that are integrative (both within and among disciplines), tap into students prior learning, allow students to "fail," and include time for debriefing.

Case Study: Synthetic Biology Belief 3

Students need time to struggle, reflect, and connect lessons learned with teachers facilitating learning through varied instructional strategies.

To develop the Synthetic Biology activity, we understood that students tend to be more familiar with microwave popcorn than with Baker's yeast, which is why the experiences begin with popcorn; however, trying to construct an explanation of why it pops is more difficult. Providing open ended questioning and time for students to explore their ideas to develop their constructs about why it pops will help students gain an enduring understanding. Most students know little about yeast, their need for growth, and are unfamiliar with equipment used, so it is inherent that errors will occur that will result in less than favorable results. Experiments and solutions will need to be redesigned and retested to determine if optimal results have been achieved. Each time students are responsible for recording what they did, what the results were, analyzing and interpreting the data, and sharing these with their peers. Students are not penalized for failures and teachers use a variety of strategies to assist with student comprehension. In this model, teachers facilitate learning by asking open-ended questions, differentiating to students' abilities and experiences, and giving students time for the repetition of practices needed to reach mastery.

Fusion Belief 4. <u>Students need to share science</u>. Science is a community of learning made even more extensive by the upgrades in technology over recent years. Students need to be able to collaborate not only in lab work by sharing responsibilities, materials, and space, but also in sharing of data, questioning other students, and defending conclusions. This belief correlates to NGSS practices seven and eight: engaging in argument from evidence and obtaining, evaluating, and communicating information.

Case Study: Synthetic Biology Belief 4

Students need to share science.

As part of our sample activity, students are asked to defend what they believe are the optimal growing conditions for baker's yeast. Their defense is based on evidence they have gained throughout their repeated experimental design, redesign, and retesting, as well as looking at growth curves of other organisms online. The class engages in a lab meeting to share results. Many skills need to occur in order for this happen. From the beginning, students work together in pairs or small groups to gather and share materials and complete experiments. Stewardship continues in cleaning up after an activity is completed. Collaboration continues in discussions. Students learn to participate in sharing of their own ideas, learning to listen to others and learning to question others' evidence and ideas respectfully. These are all important facets of students learning to share science.

Conclusion

Evaluation

The Fusion program has been externally evaluated by a variety of professionals throughout the program's history enabling us to learn lessons and adjust our focus similarly to the way we teach students to prototype. Our 2013-2014 evaluation, conducted by the Center for Evaluation & Education Policy (CEEP) at Indiana University, indicates that the Fusion program has been successful with teachers (95%), principals (100%), parents (75%) and students (79%)—all reporting that students develop a deeper interest and understanding of math and science as a result of participation. Teachers also identified a variety of areas in which IMSA Fusion improves student learning, including student abilities to:

1. Identify problems to be solved.
2. Collect, organize, and analyze data.
3. Formulate solutions.
4. Communicate orally and in written form.
5. Work with their peers to achieve common goals.
6. Integrate mathematics and science content.

Using program evaluation, educational research and partner school feedback, IMSA evaluates the program's ability to improve student success and persistence in STEM and, when appropriate, adds new values to measure the program's impact in Illinois schools.

Discussion

Science is more than a body of knowledge that students must master to be deemed scientifically literate. It is also a process for learning which teaches students to utilize critical thinking while developing, testing, evaluating, revising, and sharing claims. According to the National Research Council, "When learning science, one must come to understand both the body of knowledge and the process by which it is established, extended, refined and revised" (2007). Scientists, engineers, and mathematicians use a wide array of methods to develop theories and models and to assess and refine their work. They utilize a variety of systematic methods to collect observations, measurements and data. However, all STEM domains are rooted in a reliance on utilization of data and evidence to evaluate claims and contribute to solutions. Teaching students to effectively create, collect, evaluate and share evidence should be at the root of STEM learning from the earliest possible age. The best STEM education is deep, meaningful, hands-on, minds-on, and student-centered with wrong turns, redesign, and solutions that best fit.

Based on years of experience in STEM education, IMSA believes that the current goal of science education needs to shift from a focus on content knowledge acquisition to students working in classrooms as scientists using practices that develop their understanding of the cross-cutting concepts of science and engineering. Since the program's implementation in 2001, Illinois teachers, administrators and parents have participated and IMSA has collected evidence of increasing levels of interest, persistence and success in STEM through our model of experiential learning. We support the adoption of the Next Generation Science Standards and encourage all educational leaders to embrace the full implementation of these standards and to emphasize the importance of STEM education in all of our schools in order to prepare fully students for college and the world of work.

The internationally recognized Illinois Mathematics and Science Academy® (IMSA) develops creative, ethical leaders in science, technology, engineering and mathematics. As a teaching and learning laboratory created by the State of Illinois, IMSA enrolls academically talented Illinois students (grades 10-12) in its advanced, residential college preparatory program, and it serves thousands of educators and students in Illinois and beyond through innovative instructional programs that foster imagination and inquiry. IMSA also advances education through research, groundbreaking ventures and strategic partnerships. www.imsa.edu.

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Interview with Anna Laky

Success in High-Need Schools Journal editor Jerry Berberet interviewed Anna Laky, a third year physics and chemistry teacher at Maine East High School in Park Ridge, Illinois, on her motivation to be a science teacher and her goals for her students. She commented on the background and science preparation of her students and the impacts the New Generation Science Standards may have in improving student learning.

1. Please tell *Success in High-Need Schools Journal* readers about your background, why you chose a teaching career, where and what you teach in your current position, and the grade level you teach.

I currently teach physics and chemistry at Maine East High School in Park Ridge, Illinois. Most of my students are sophomores and are being exposed to many physics and chemistry concepts for the first time. I chose to become a teacher because I want to help students learn science so that they can understand more about the world around them. I think that teaching science is unique because I am able to explain a lot of things that students see in their lives every day that make it more interesting for them to learn. I chose to teach at the high school level because during my high school experience my teachers were more than just teachers; they were mentors as well. I want to be able to mentor students as they look toward what they want their future to be.

2. Describe the background and preparation of your students. What are your goals for their achievement?

Maine East High School has a diverse student population. Our students come from many cultural backgrounds. There are over 50 languages spoken in the homes of our students so their heritage and where they come from are important to them. In addition to their culture each student brings a different set of previous experiences that they can apply in the classroom. One goal I have for students is to make connections with their prior knowledge and to relate it to something they see or do currently. I also want my students to be able to learn not only science content but also life skills in the classroom that they can apply in their future. I hope that students will realize that they have so many options for careers and that science could be one of those options.

3. How familiar are you with the Next Generation Science Standards (NGSS) movement? How do you feel NGSS will improve science and math education?

I have been to a few conferences that had sessions on NGSS in the past year. Science teachers will need opportunities for professional development when it comes to incorporating NGSS in their current classrooms. I think that NGSS presents a new way of teaching as well as a new way of thinking and interacting with the content for students. NGSS presents an applied, integrated approach that students may have never experienced. Based on what I know about the standards, I feel that my teaching will be moving more towards problem-based learning, inquiry, and other student-led investigations. With these types of activities, students are able to work on a problem, pull from their prior knowledge and take their learning to a higher level. This way of teaching will allow students to take charge of their learning more; helping them to develop knowledge from the content but also lifelong skills like identifying patterns, cause and effect relationships and relating concepts to current technology.

4. Please describe the challenges and opportunities you face in seeking to improve the science and math achievement of your students.

The hardest thing is probably that my students come in with different levels of prior knowledge. We are currently working with one of the feeder middle schools to align our curriculum so that we know what they are learning in middle school to prepare them for the high school science classroom. I think that as we work through what they already know we will be able to help students learn the concepts better. This is particularly helpful when we work on problem-based learning units where drawing on previous knowledge is important. Professional development for teachers will be key opportunities that we can take advantage of, particularly in areas like aligning curriculum and assessments to NGSS.

5. What do you find most rewarding as a teacher? Most challenging?

I think that the most rewarding thing is to be able to see students grow as they learn and apply the concepts that I teach them. My favorite thing is when students come to class and tell me about how they have seen physics that we are learning in their lives.

The most challenging thing for me is to be able to reach each student at his or her level. In my classroom the levels of students prior knowledge is so varied sometimes that it is hard to differentiate so that all of my students are successful.

6. What are your long-term career goals?

My goal throughout my entire career is to continue to make a difference in students' lives. I want to always have as much excitement about teaching ten years from now as I have today in my second year of teaching. I think that what I want to see out of my career is that I continually attend professional development workshops and classes so that I am becoming the best teacher I can be for my students. My goal is to be able to help students where they are each year, helping them achieve success in science.

State Farm Supports Teachers
by Kathy Havens Payne

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State Farm® is proud to support teachers. We believe private sector engagement is critical to help raise awareness of the importance and impact of the profession. Great teachers help motivate and develop great students, who in turn can improve our nation's economy and global standing. It's a goal we can all rally around.

There are many ways this increased awareness can be accomplished. State Farm partners with numerous education policy organizations that work to create robust state and federal policy to improve conditions for teachers, support ongoing development and create an atmosphere where meaningful reform can occur. We support the implementation of the college and career ready standards that 45 states are now undertaking because we believe that these standards will level the playing field for children. But for the standards to be implemented effectively, teachers need and deserve high quality professional development.

In the private sector, we often take the ongoing development we receive for granted. Yet, many in the teaching profession are denied ongoing development for a variety of reasons, chief among them is budget cuts. All professions require continual development to help hone new skills, practice new approaches and to advance lifelong learning. Teaching should not be excluded from nor denied this tenet of professional practice.

At State Farm our philanthropic portfolio focuses on supporting efforts that create safer, stronger, better educated communities. A pillar of our education philanthropy is support for quality teaching. We've maintained this area of focus for over a decade because we believe good teachers are essential to improved educational outcomes for students.

By continuing to focus resources on teaching as a career, the business community can be – and should be – a powerful advocate for ongoing efforts to improve teaching that impacts results for students. We all need to demonstrate that we value the profession of teaching. Think about it. If you're a doctor, lawyer or business leader, you learned what you needed to know from great teachers. Yet, in our society, teaching is often not an aspirational career. Too many students are counseled away from teaching and pushed instead toward careers that garner more outward societal respect and financial rewards than those afforded to teachers.

We work with great partners such as the National Board for Professional Teaching Standards and Teach for America to propel the teaching profession forward. Through these and other organizations, our goal is to support efforts that enhance and highlight the teaching profession and increase both recruitment to teaching and retention of great teachers. We know that there are great educators throughout the country that work hard every day to change their students' lives. As a business, we can best help by highlighting their efforts, support organizations that improve conditions for teachers and encourage a focus on outcomes for students.

State Farm is a founding board member for a new public/private partnership called TEACH. It includes a dynamic Website (Teach.org) filled with resources for teachers and includes a multi-pronged strategy for recruiting the next generation of diverse teachers. Through a strong presence on selected college campuses, student ambassadors and campus recruiters will help encourage students to consider teaching as a career. Campus events and numerous materials will be used as platforms to inform and inspire students who might otherwise not think of teaching as their career of choice. A social media campaign has been launched along with a series of ads by the Ad Council to enhance perception of teaching and to encourage more to enter the profession.

The tagline for the TEACH campaign is *Make More*. Some people may think the tagline indicates financial rewards. While there is significant work that needs to be done to bring teacher salaries in line with those of other professions, *Make More* is not about money. It's about making a real difference by the work you do. It's about changing lives directly – something that good teachers **know** they do. We hope TEACH will encourage smart, talented "young" and "not-so-young" people to choose teaching as a career. Because when you teach, you're a significant influencer in the trajectory of a child's life. You *Make More.*

Teaching Young Scientists: Reflections on bringing NGSS into the classroom
by Pamela Wagner

Author Bio

Pamela Wagner graduated from Knox College and is a HS science teacher in the North Lawndale neighborhood in Chicago. She recently received her National Board Certification in Science. She can be reached at pammwagner@gmail.com.

Column

When I first heard about the Next Generation Science Standards, I first wondered how will this affect my students' learning? Every student is a scientist in my classroom. I teach them to collaborate as scientists and to think scientifically. I will speak for my colleagues that they do the same. Teaching in a mostly African American, high poverty school in Chicago, I know that historically very few students entered a career in a science or engineering field. It is well known in my field that minorities are underrepresented in the STEM fields, so as I read about NGSS and attended workshops over the past few years, the question on my mind has been: how will NGSS support the scientific thinking of my students?

As I have learned about the NGSS I have slowly incorporated components into my curriculum. Although this has felt like a slow moving process, I regularly add a performance expectation into my curriculum and adjust units of study.

There is much I like about the new standards. I have a clear idea of how these standards were generated, why they were generated, and what level of understanding is expected of students. The performance task actions are high on the critical thinking scale. About a week ago, we started our first engineering problem of the semester in my 9th grade courses. Students began by defining the criteria needed in order to evaluate our designs. This part was vital to the design process; students felt empowered to be part of this designing of criteria, and seem to own the testing process and experimentation that followed. Students are learning science and asking deep questions about design already this fall. Planning units like this are supported by NGSS. Performance expectations with phrases like "analyze," "plan and conduct," and "communicate scientific information" spark the creation of student-centered lessons and get me excited about planning my next unit. Having the NGSS as a reference has given me ideas for lessons that I am confident are backed up by experts who wrote the standards. NGSS performance expectations make a good starting point as I plan the unit backwards. For example, when planning a Newton's law unit, it was easy to decide what performance task I wanted my students to accomplish (taken right from the NGSS performance expectation). With the correlating science and engineering practices, core ideas, and crosscutting concepts so accessible, I plan the rest of the unit using these elements.

The NGSS connections with common core literacy standards facilitate interdisciplinary work. Reading and writing skills are embedded in the performance expectations but also discussed through the science lens in our interdisciplinary projects. Having them connected to NGSS core ideas focuses these skills during certain units.

Mathematics connections now receive greater emphasis in my teaching. During the past few years we have incorporated components of mathematical modeling to define and understand physics concepts in my senior physics course. Many of the physical science NGSS ideas include using mathematical models. These models are introduced and constructed with student-collected data in order to help them understand some of the physics concepts constructed through these models. Using student experimental data also opens up an opportunity for students to collaborate as scientists. This is another key component in the NGSS. Through teaching strategies I learned in workshops around the Modeling Physics Curriculum, students have become better scientists. They can question each other's data, defend their conclusions based on their own data, draw conclusions from several experiments done by several groups, and learn from each other. When I say "design an experiment" they begin to identify their variables and are usually ready to start before I say go. There comes a point mid-semester when we have a lab discussion and I barely say anything—my students are doing science without me. Although students struggle at this change in learning style at first, they thrive in their discussions as the course goes on. It is exciting to see these things emphasized in the NGSS because it is supporting scientific thinking in my classroom.

This year, I look forward to deepening student learning around the 21st century issues embedded in the standards. Repeatedly and across grade levels issues of global climate change and related human impacts are raised in the NGSS curriculum. These are issues that could affect our students significantly during their lifetimes, issues important for them to understand deeply.

As I have mentioned, there is a lot about the NGSS that excites me. I am encouraged by the interdisciplinary connections they enable students to make and the way that they reflect contemporary approaches to science. The heightened critical thinking reflected in each performance expectation inspires me as I am able to use it as a support in raising the bar of critical thinking in my classroom. It is also very affirming to see some of the same research based ideas I use as I teach science reflected in the standards themselves.

However, there are some challenges around standards that I still feel we need to address. First, these are K-12 standards. Many of my students come from schools where science education is not supported to the extent that is needed. Some of my friends who are not K-8 teachers have read some of the science standards and been hesitant to increase rigor and levels of content. Increasing content is not difficult in teaching the lower grades, but how do we support teachers in implementing new content and curriculum? How do we make time for good science instruction (both planning and teaching)? Many of the standards I am tackling right now in my physical science course are marked as middle school standards in NGSS. How do we bring more science into our classrooms early and continuously throughout K-12? These standards build on one another, and we educators need the time, resources, and support to build them into the K-12 curriculum effectively. One of the things I have heard repeatedly when NGSS is brought up is that these standards are for all students and that many of our current and future challenges revolve around STEM. Thinking of this and the students I teach—my next concern is how do we implement the standards effectively on a large scale? How do I increase my students' knowledge of science and engineering and how do we expand the pipeline of students entering the STEM fields? I am encouraged by the research and thought evident in creating the NGSS and hope this *momentum* continues in implementation.

"Hiring Good Teachers to Succeed in High-Need Schools"
Interview with Paul Goldberg, Ed.D.

Bio: Paul Goldberg, Ed.D. is principal of John Muir Literacy Academy in Schaumberg, Illinois. He can be reached at PaulGoldberg@sd54.k12.il.us.

1. Please describe your educational and professional background, your current position, and the time period in which you have worked in human resources.

I am currently the principal at John Muir Literacy Academy in Schaumburg School District 54 and was previously the principal at Robert Frost Junior High School in the same district. Prior to serving as principal, I was an assistant principal of a junior high and a fourth grade teacher. My education took me from the University of Illinois in Urbana-Champaign as an undergraduate in Speech Communication to National-Louis University for my Masters in Teaching and then to Loyola University Chicago for my doctorate in School Administration and Supervision. While not directly in the human resources department of our district, I am responsible for interviewing and hiring and the evaluations of all staff. In typical years, I hire about 15 teachers and support staff, evaluate about 30 staff, and deal with all human resource issues at the school level.

2. What are the priorities of your school district in hiring new teachers? Are you finding an adequate supply of teachers who are well-qualified to fill vacant positions in your district?

Our main goal in hiring teachers is finding teachers who achieve our Board goals and our mission of Ensuring Student Success. We strive to find certified educators with exceptional abilities in planning and collaboration, teaching and learning, developing a positive classroom environment, and professionalism. Finding enough teachers who can immediately achieve these goals and positive student learning results, especially in hard to find areas like bilingual and special education, remains a challenge. We ultimately do have a vast candidate pool and can typically find top candidates, but for certain jobs even including upper elementary classroom teaching positions, it often takes 20 or more candidate interviews to find the right match.

3. What are the most important qualifications you seek in candidates for teaching positions in your district? Does your district have partnerships with college level teacher preparations programs where your hiring priorities can be addressed?

   - Ability to achieve exceptional student learning gains
   - Ability to build and maintain positive relationships with students, staff, and the community
   - Ability to manage a classroom in a positive way, especially one with students who present management challenges
   - Ability to engage all students and teach using best practices in literacy and math
   - Ability to collaborate, analyze data, and make decisions based on research, best practice, and data

- Schaumburg School District 54 has a developing partnership with North Central College and has strong relationships with other area schools to recruit educators. In my experience interviewing first year educators, North Central is preparing more good candidates more of the time than any other school I consistently see on resumes.

4. How do current teacher education program reforms and state policy initiatives of which you are aware address the qualifications you are seeking in new teachers? What additional reforms are needed?

I would suggest teacher education programs begin to prepare all teachers for immediate success at the proficient level within the Danielson Framework, with an understanding of Professional Learning Communities. If there were a rigorous expectation to be proficient based on the Danielson appraisal model, teachers would immediately be prepared for success. While it is not a simple change, if student teaching lasted at least one year, in the best schools with the best educators in those schools, everyone would benefit. If this were an expectation instead of a nicety, new educators would benefit as would our students. Once the aforementioned reforms were in place, I would then suggest we begin recruiting our best and brightest from high school directly into these programs. Reflecting on how countries like Finland recruit top candidates or how the medical field prepares doctors before they begin practicing on their own would be a great step.

5. How diverse is the teacher corps in your district? Does your district actively recruit a diverse group of teachers?

Our school district does actively pursue diverse candidates when it recruits educators. Our diversity level does not yet mirror our student population but likely does mirror the diversity of the candidate pool.