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On the Cover
Photo by Sunny Ou, Student, High School for Math, Science and Engineering at CCNY, New York, NY
The Verrazano-Narrows Bridge as seen from the Brooklyn waterfront, March 23, 2014
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One of the significant values of being a part of NCSSSMST is the opportunity to see the wide range of teaching and learning practices being used in schools across the country. From California to New York and from Michigan to Florida, if you can imagine a combination of various races, ethnicities, languages, or socioeconomic statuses, there is a school in the Consortium that could probably match it. In talking with the leaders of many of these institutions, there is a common thread: we value diversity greatly but have not found the magic answer to fully meet the needs of groups that are underrepresented in our schools. The truth is that this is a multi-layered, complex issue that cannot be addressed with a simple “diversity” policy. Additionally, this situation will never fully diminish throughout our schools. There will always be student groups that are systematically marginalized if we are not intentional in reaching out to all of our populations. Hence, that is what we need to do: be intentional in creating equity for each child within our reach. With that said, the real work is answering how we do this.

The next two issues of our journal seek to open that dialogue across NCSSSMST. What are our best practices? How have we addressed these issues in our communities? Included in the following pages are articles about gender differences in the sciences, differences in motivation among learners, and calls to dialogue and action in addressing diversity issues. But we also use this issue to invite you to a larger conversation in addressing this topic. We have created a Quick Start Guide for you to employ as a template in developing an article for submission to the next few issues of the NCSSSMST Journal. We hope you will accept our invitation.

There are times that trying to create an inclusive, well-represented school is overwhelming. In those moments in my life, I am reminded of the story of the Starfish Thrower. As a young man is trying to save a beach full of stranded starfish, he is told by a well-intentioned adult that the beach is too long for him to ultimately make any difference. The boy just smiles, picks up a starfish, and says, “It makes a difference for this one” as he tosses it back to safety. I have names for my starfish over the years: John, Shelby, Seth, and Anticia; Riley, Dominique, Wayne, and Vishnu; Manny, Brittney, Micaela, and Josh, to name just a few. But the important thing to remember is that every child has a name and each one has a right to grow to his or her fullest potential so that they can be equipped to engage in our world in a beneficial way. The reality is that we cannot afford not to invest in all students. We need them all.

— Tim Gott

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Tim Gott, Ed.D., is NCSSSMST President and Director of the Carol Martin Gatton Academy in Bowling Green, KY.
Growth Mindset of Gifted Seventh Grade Students in Science

by Julie Esparza, Lee Shumow, Ph.D. & Jennifer A. Schmidt, Ph.D., Northern Illinois University

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ABSTRACT

Through secondary analysis of data collected in middle school science classrooms, this study (a) compared gifted and regular students’ beliefs about the malleability of intelligence in science; (b) investigated whether teaching gifted and talented middle-school students about malleability of the brain and study skills helped them to develop a growth mindset (Dweck, 2000), and (c) examined whether there were teacher effects in the impact of the intervention. Compared to the general student population, gifted and talented students were more likely to endorse the idea that intelligence is malleable, but there was considerable variability among gifted students’ mindset beliefs. Results of a mixed between-within subjects ANOVA showed a large effect size in the impact of the six week mindset intervention (Brainology) among the gifted and talented students. While strong teacher effects on growth mindset were found among students in the general population who participated in the intervention, similar teacher effects were not found among the gifted and talented students. A growth mindset is particularly important for gifted students because they are at risk for both under-achievement and perfectionism, which may hinder them from reaching their potential.

Gifted students who reach their potential are likely to make contributions to society by solving problems and making advances in their chosen fields. Expertise in STEM fields like medicine, engineering, economics, and psychology is especially needed (Committee on Prospering in the Global Economy of the 21st Century, 2007). Unfortunately, many gifted students do not reach their potential (Adams et al., 2008), which has consequences for them and for society at large.

Under-achievement, perfectionism, and helplessness have been identified as barriers that contribute to academic disengagement and prohibit gifted and talented students from reaching their potential (Carr, Borkowski, & Maxwell, 1991; Fletcher & Speirs Neumeister, 2012; Roedell, 1984). Students with a growth mindset, who believe that intelligence is malleable, are less likely to manifest academic under-achievement or maladaptive perfectionism than their peers who believe intelligence is fixed (Siegle & McCoach, 2005). Studies have shown that teaching students in the general population about growth mindset can help them overcome these conditions (Dweck, 2000; Shumow & Schmidt, 2013), but little is known about the mindsets of gifted students or about how gifted students respond to education designed to enhance a growth mindset in specific subject areas such as science. This study addresses those gaps in the literature by investigating gifted middle school students’ mindsets in science.

Mindset

Dweck (2012) describes a growth mindset as one in which a person believes that his/her intelligence is malleable and can grow. Students with a growth mindset tend to embrace challenges, persist in the face of obstacles, perceive effort and study strategies as a means to learn, utilize feedback to improve, and find inspiration in the success of others.
In general, they have a mastery goal orientation focused on learning. In contrast, a fixed mindset describes the belief that intellectual ability is a fixed trait that one cannot change (Dweck, 2012). Students with a fixed mindset prefer to look smart by succeeding at easy tasks, quit when obstacles arise, perceive effort as a sign of low ability, reject constructive feedback, and are threatened by the success of others. In general, fixed mindset students have a performance goal orientation focused on besting others and preserving an image of smartness and ability.

According to decades of research by Dweck (2000), approximately 40-45% of young adolescents have fixed mindsets, and the same percentage has growth mindset, with about ten to fifteen percent falling in between. Growth mindset beliefs predict higher achievement and greater effort than fixed mindsets for students from early childhood through college (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2006). The present study investigates the mindset of gifted students in science; much of the prior research has focused on students in regular education in mathematics.

**Mindset of gifted and talented students**

Little is known about the mindset beliefs of gifted students. Teachers sometimes express the misconception that gifted students hold growth mindsets (Shumow & Schmidt, 2014), but Dweck (2012) recently suggested that identified gifted students are at risk of developing fixed mindsets. She speculates that this may be caused by the labeling of gifted students and/or the way they have been praised for their intelligence by parents and teachers (Dweck, 2007). Researchers have found that gifted students tend to have greater intrinsic motivation than their peers in regular education (Clinkenbeard, 2012), but we found no studies comparing mindsets of gifted and regular education students.

We investigated the science mindset of identified gifted and talented middle school students and whether it differed compared to other (regular education) students in their science classes. As subsequently described, mindset may be an important underlying factor in the failure of gifted students to reach their potential.

**Mindset and under-achievement in gifted and talented students.** Mindset is a likely contributor to underachievement problems that have been observed in some gifted students. One reason for underachievement among gifted and talented students is that the school curriculum is not challenging for them; they often learn more quickly than other students and may already know much of what is being taught in the classroom (Reis et al., 1993). Gifted students who subscribe to a fixed mindset are likely to rest on their laurels. Further, they may believe that if they have to work hard at learning, this is a signal that they are no longer smart. One study indicated that middle school students who endorsed fixed mindset of learning declined in motivation to learn whereas those with a growth mindset were motivated to learn more (Haimovitz, Wormington, & Orpus, 2011).

**Mindset and perfectionism in gifted and talented students.** Perfectionism, which describes the inner drive to achieve excellence, operates differently for people with fixed and growth mindsets (Diehl, 2014). Perfectionists with growth mindset endorse the view that errors are part of the process of achieving excellence. However, perfectionism can become maladaptive resulting in crippling anxiety or paralysis. Wang, Fu, and Rice (2012) found that gifted students with maladaptive perfectionism held performance goal orientations, which are indicative of fixed mindsets.

**Mindset and helplessness orientation in gifted and talented students.** Carr, Borkowski, and Maxwell (1991) believe that motivational beliefs underlie helplessness orientation. Dweck (1975) found that students with a helpless orientation display the fixed mindset tendency of blaming failure on lack of ability and fall into the trap of believing that if they have to work hard, they must not be very smart. Consequently, when they make mistakes, they may try to hide them rather than repair them. Further, students with a fixed mindset try to preserve their self-image by withdrawing from challenge and may lack strategies that allow them to deal with challenge. In contrast, students with a growth mindset persist when faced with failure, consider challenge an opportunity, and work hard with the intention of becoming better and smarter.

**Mindset Interventions**

Given the negative consequences of holding a fixed mindset, it is important to find methods of encouraging a growth mindset in students. Initially, as detailed in Dweck (2000), researchers demonstrated that they could successfully change students’ mindsets. Efforts were then made to implement mindset interventions in schools. Students were taught about how the brain responds to learning and how to use study strategies to learn (Dweck, 2012). The combination of teaching middle school students both about the brain and study skills increased their (a) beliefs about the malleability of intelligence, (b) desire to learn, and (c) their mathematics grades (Blackwell, Trzesniewski, & Dweck, 2007). Shumow and Schmidt (2013) recently implement-
ed a similar mindset intervention in seventh grade science classrooms as part of a larger research project called Incremental Mindset and Utility for Science Learning and Engagement (or IMUScLE). In the IMUScLE Project, participants became more likely to endorse beliefs about the malleability of intelligence after participating in the intervention whereas students in the control group did not. The present study investigates the results of the intervention among the gifted and talented students who participated in the IMUScLE study.

Teacher effects on student mindset

Recently, teacher effects were identified within a mindset intervention with seventh graders (Shumow & Schmidt, 2013). Those teacher effects were related to teachers’ support for or undermining of growth mindset beliefs during science instruction. Teacher effects can be expected for several reasons. First, teachers with a growth mindset provide more encouragement and teach more learning strategies to students, which may in turn influence growth mindset in students (Dweck, 2008). Second, it is likely that teachers amplify or dampen the impact of an intervention by how faithfully they implement the intervention (the follow up activities in this case). Finally, teachers vary in the amount of challenge they present to students, the ways that they respond to error, and the opportunities they provide for improvement.

Most studies that focus on teacher effects have been conducted within either regular-education or with under-performing students. Very few studies have looked at the influence of teacher attitudes on gifted students. Seigle and Reis (1998) studied whether gifted students’ beliefs about their own ability, effort and work aligned with those of their teachers. In that study, gifted students differed from their teachers, which may suggest that they were relatively impervious to some teacher attitudes. This study investigates whether the teacher effects that were evident in the general population occurred within the population of gifted students.

In summary, this study investigates three questions. First, what do gifted students believe about the malleability of intelligence compared to regular students? Second, do gifted students who participate in a mindset intervention during science class increase in growth mindset compared to a control group? Third, what was the effect of the teacher on the mindset intervention for both gifted and regular students?

METHOD

Data used in this paper were collected as part of the Incremental Mindset and Utility for Science Learning and Engagement (IMUScLE) Project (Schmidt, Shumow, & Durik, 2011), a quasi-experimental study designed to test the impact of targeted treatments on male and female students in science classrooms.

Setting

Data were collected during the 2011-2012 school year. Students from all the seventh grade science classrooms (n = 16) in two middle schools within a district serving students from a diverse community located on the fringe of a large metropolitan area participated.

Participants

Altogether, 380 seventh grade students participated in the study (mean age = 12.24). Participation rate across all seventh grade classrooms was very high with several of the classrooms studied having 100% participation. The seventh grade sample was 45% male and 55% female. The sample was 22% White, 42% Latino, 11% African American, 3% Asian, less than 1% Native American, and 22% multi-racial. According to school records, 61% of students in the sample were eligible to receive free or reduced lunch. Forty-four percent of the students in the sample reported that neither of their parents had attained a college degree. Twelve percent said that at least one parent had graduated from college, and 11% indicated that at least one parent had earned an advanced degree. Thirty-three percent of students in the sample did not know their parents’ educational attainment.

Eighty of the students had been identified as gifted and talented by their school district by using standardized test scores, teacher evaluated learner characteristics, and grades. Among the gifted student seventh grade participants 44% were male and 56% were female. The gifted sample was 38% White, 30% Latino, 7.1% African American, 1.2% Asian, and 23.8% multi-racial. According to school records, 37.3% of the gifted students in the sample were eligible to receive free or reduced lunch. Gifted students were enrolled in the regular science classes and received occasional and unsystematic pull out enrichment. Among this group of gifted identified students, 21.25% were enrolled in a NCSSSMST school after school enrichment program.

Students in seven classrooms received the mindset treatment. Students from the remaining nine classrooms,
served as controls for the mindset treatment.

**Procedures**

**Brainology Intervention.** The Brainology intervention consisted of an interactive online software program based on Carol Dweck’s mindset research. The goal of the program is to encourage a growth mindset in learners. It teaches: how the brain works; that effort and leaning strategies will improve one’s intelligence; and how lifestyle choices along with study skills facilitate learning and growth. Students participated in the interactive program for six weeks. The program was completed either in the school’s computer lab or using laptops in the science classroom, depending on available resources for that class. One full class period per week was devoted to the program supplemented by brief homework assignments or additional in-class activities on other days. Each week, the program included an opening activity led by one of the IMUScLE researchers, followed by the computer module section that introduced content knowledge and provided frequent opportunities to both apply the knowledge and reflect on the material in an “e-journal.” Following the completion of each module, students were given a follow-up activity (this was completed as homework if they did not finish in class) and participant teachers selected additional supplementary activities from the Brainology teachers’ manual to reinforce relevant concepts during the week.

**Student Survey**

**Student mindset.** Four items were used to measure students’ beliefs about the malleability of intelligence. The items asked students to report on a six-point scale (from disagree a lot = 1 to agree a lot = 6) whether they believed it was possible to change one’s intelligence in science (2 items) or whether science intelligence is fixed (2 items which were reverse scored to create this variable). A factor analysis provided evidence of the construct validity of this subscale. Cronbach’s alpha for these items was: .60 in the initial survey, .74 in the post intervention survey, and .74 in the follow-up survey. Items were drawn from published studies (Aronson et al., 2002; Blackwell et al., 2007), which reported test-retest reliabilities ranging from .77 to .82.

**RESULTS**

**Comparison of Growth Mindset between Gifted and Regular Education Students**

Before the intervention, gifted students’ beliefs about the malleability of intelligence in science were compared to the beliefs of students in the general population. Gifted students (M = 4.5, s.d. 1.1) were more likely to believe that intelligence in science was malleable (t = 4.24, p < .001) than were regular education students (M = 3.96, s.d. .73). Inspection of the means indicates, however, that there is room for growth in the mindset of both the gifted and the regular education students. Inspection of the standard deviations further indicates that there is considerable variability in the growth mindset of the gifted students.

**Impact of the Brainology Program on Growth Mindset of Gifted Students**

IMUScLE project data were analyzed to compare change in mindset beliefs about the malleability of intelligence of the 32 gifted and talented seventh grade science students who participated in a six-week computer-based intervention (Brainology) with 48 gifted and talented students who served as controls. A mixed between-within subjects ANOVA was conducted to assess the impact of the Brainology program on the students’ growth mindset from preintervention to postintervention. Results can be seen in Figure 1. There was a significant interaction between time and Brainology, Wilk’s Lambda = .86, F(1, 78) = 12.6, p < .001, partial eta squared = .14 indicating a large effect size.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (n=48)</td>
<td>4.54 (.96)</td>
<td>4.41 (1.0)</td>
</tr>
<tr>
<td>Intervention group (n=32)</td>
<td>4.42 (1.3)</td>
<td>5.19 (.90)</td>
</tr>
</tbody>
</table>

**Table 1. Growth Mindset of Gifted Students by Time and Intervention Group**

Gifted and talented students who participated in the Brainology intervention increased in growth mindset. In further analyses, which are not shown, that change was maintained through the follow-up demonstrating the lasting effect of the intervention.

**Change in Belief about Malleability of Intelligence by Teacher**

Contrary to the results in the overall population, no teacher effects were found for the gifted students. Change in the gifted students’ beliefs about the malleability of intelligence was not moderated by teacher. Rather, the observed change in gifted students’ mindset was similar across teachers.
Mindset describes an important constellation of beliefs that can explain whether and how gifted students might realize their potential. Students with a growth mindset are more likely to seek out opportunities to learn, extend beyond assigned requirements, pursue learning opportunities both in and out of class, embrace and persist in the face of challenge, and utilize both feedback and study strategies to improve. Students who hold a fixed mindset are likely to be at risk of adopting maladaptive and counterproductive educational patterns. For those reasons, educators of gifted students can benefit from a solid conceptual understanding of mindset and from empirical evidence about how to promote growth mindset among their students (Clinkenbeard, 2012). Little empirical evidence has been available about mindset among gifted students.

The first purpose of this study was to estimate and compare the mindset beliefs of gifted and regular education students. Consistent with the speculations expressed by teachers (Shumow & Schmidt, 2013), gifted seventh-grade students participating in this study were more likely to believe that their intelligence in science was malleable than were their regular education classmates. Nevertheless, there was considerable variability among the mindsets of gifted students. Fewer gifted students fell into the fixed mindset range than regular students. Yet, for many, there was room for growth.

The second purpose of this study was to examine how gifted students responded to an intervention aimed at increasing growth mindset. This study showed that gifted and talented students changed the way they viewed their own intelligence after they were taught about how the brain works and techniques for learning. Changing student mindset to a stronger growth orientation may prevent and remedy motivation issues and other problems that prohibit gifted and talented students from reaching their potential. Moreover, teaching growth mindset is an affordable intervention that has effects past the initial instruction.

The final purpose of this study was to ascertain whether there were teacher effects in the extent to which the intervention impacted the increase in growth mindset among the gifted student participants. A previous analysis of data collected for the broader study (Shumow & Schmidt, 2013) found that, although students in the general population increased in growth mindset in both teachers classes, students in one teacher’s classes improved more than students in the other teachers’ classes in the extent to which their growth mindsets increased. The teachers’ discourse during science instruction and their beliefs about motivational strategies were consistent with those changes. The teacher whose students increased more expressed beliefs and used practices that promoted growth mindset more and fixed mindset less than the other teacher. This study indicates that the benefits of the intervention were not moderated by teacher for the gifted students as they were for regular education students. This finding suggests that the gifted students were able to override the teachers’ beliefs and practices given exposure to knowledge about neurophysiological changes in the brain associated with learning, mindsets, and methods that students can use to control their learning.

Without intervention, we might have seen a greater influence of teachers’ beliefs and practices in the classroom on the gifted students. Based on her extensive experience...
studying mindset, Dweck (2012) recently expressed a concern that gifted students are at risk of developing a fixed mindset because of the messages they receive about ability. Although one recent study uncovered no differences in mindset beliefs between high-ability students as a result of being labeled as gifted in the academic setting (Snyder et al., 2013), daily messages about ability and effort might influence mindset among gifted students if those students are not given access to information that counteracts it.

This study did not directly address the underachievement, perfectionism, and helplessness orientation that may undermine gifted students’ realization of their potential. Rather, it focused on a likely factor underpinning those maladaptive patterns. Future studies are needed to connect those constructs with mindset. The findings of this study also suggest that it would be beneficial to test other interventions (Yaeger & Dweck, 2012; Yeager, Paunesku, Walton, & Dweck, 2013) aimed at enhancing growth mindset among gifted students specifically.

In our society, highly capable children and adults are a precious commodity. They must be nurtured and valued. Our nation has spent the last decade focusing on students who were not making adequate yearly progress. Educational resources were invested in students who were not achieving grade-level specific outcomes and very little effort was put toward moving above-level students upward. Therefore many became disengaged from school. Teaching these students about growth mindset and how they can improve their own learning experience is a step toward remedying that neglect.

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Lee Shumow, Ph.D., is a professor of educational psychology at Northern Illinois University.

Julie Esparza is Gifted and Talented Program Coordinator in West Aurora (IL) School District 129.

Jennifer A. Schmidt, Ph.D., is a professor of educational psychology at Northern Illinois University.
The Dilemma of Excellence and Diversity

by Crystal Bonds, The High School for Math, Science, and Engineering

During my three years as a new principal at The High School for Math, Science, and Engineering (HSMSE), one of New York City’s eight specialized high schools, I found myself constantly wrestling with two challenges: maintaining the school’s high academic standards and protecting the school’s extraordinary diversity. Among the city’s eight specialized high schools, HSMSE usually ranks 4th or 5th in the cut scores needed for acceptance based on a standardized admission exam.

At the same time, according to The New York Times, HSMSE ranks first among all New York City high schools in the diversity of its student body. I see my overall mission as not only maintaining but even improving the school’s academic excellence and also preserving our distinction for ethnic and racial diversity.

Academic Excellence

When I use the words “academic excellence,” I don’t merely refer to such usual measures as college acceptance rates, average SAT scores, and Advanced Placement courses (we are doing very well in all these areas) but rather the rich academic programs available to our students in the areas of math, science, and technology. Despite the school’s small size (450 students) and in order to meet the diverse interests of our students, sophomores select one of three major concentration tracks: Advanced Engineering, Mount Sinai Biomedical Research, or an accelerated mathematics strand.

Advanced Engineering Program

The Advanced Engineering Program offers students a continuation of the pre-engineering program offered in collaboration with Project Lead the Way. Juniors take courses in Digital Electronics and Principles of Engineering; seniors select from Innovation and Design, Networking, and Advanced Civil Engineering & Architecture. Beginning in the summer before junior year, our Engineering students have the opportunity to apply for a paid research internship at CCNY’s Grove School of Engineering, and may continue through the school year.

Mount Sinai School of Medicine Biomedical Research Program

This program was designed and implemented in collaboration with scientists and physicians at the Mount Sinai School of Medicine. The two-year program consists of advanced laboratory experiences and a research internship in one of the medical specialties such as cardiology, oncology, obstetrics and the autopsy suite. The first-year course is an introduction to the basic concepts and laboratory skills used in the field of DNA and hybridoma technology. During the second year, participants are placed individually in two clinical or laboratory internships at the Mount Sinai Medical Center.

These internships provide students with understanding, knowledge, and skills related to DNA and biotechnology, preparing them for college, graduate, and professional school. The program exposes the students to career possibilities in biotechnology and also allows them to explore other areas of interest. Students must also write a science research paper suitable for entering into regional and national competitions.
Mathematics Concentration
The Math Concentration at HSMSE provides excellent experience and opportunity for students who are interested in higher mathematics and computer science. Students explore the creative and less conventional areas of math that ordinary high school classes do not cover. Juniors take two college credit-bearing courses, Pre-Calculus and Calculus, as well as AP Statistics. They are expected to take the Principles of Engineering course as well. In 12th grade, most students will take AP Calculus BC and a full-year course entitled, “Advanced Topics,” comprising Graph Theory, Number Theory, Game Theory, Problem Solving, and Maple programming, a full computer programming language designed for mathematical computation.

All students in this concentration are required to complete at least two semesters of Varsity Math Team. Furthermore, students have opportunities to go beyond this curriculum by participating in college courses, local and national math research fairs and competitions, independent research projects and robotics.

THE SCHOOL’S ACADEMIC CULTURE

Literacy at HSMSE
Long before the introduction of The Common Core State Standards, HSMSE emphasized the importance of reading texts across the curriculum, conducting research, and writing formal papers that meet the highest standards.

All freshmen enroll in an Introduction to Research course, in which they are introduced to theories and methodology of research across the disciplines. In the sophomore year, students conduct research in science; in the junior year research is conducted in American history classes. All seniors are required to produce an argumentative research paper in an English Department course that is designed to prepare them for writing at the college level.

Teachers as Professionals
Another reason for the success of our school is the faculty’s acceptance of high standards of teacher professionalism. Teachers don’t just hold students to high academic standards, but also hold themselves to exacting standards. The teachers regularly reexamine their teaching methods, revise their lessons, and refine their curriculums. An excellent example of this constructive approach was the teaching staff’s success in translating a bureaucratic Department of Education mandate into a tool that helps us better understand the needs of our students.

In 2007, the NYC Department of Education promoted the creation of Inquiry Teams in every school as a core component of its school improvement strategy. Each Inquiry Team was charged with becoming expert in using data to identify a change in instructional practice (2008, NYC DOE). Inquiry Teams were reorganized to focus on the areas of need based on each school’s Progress Reports, high stakes testing and inherent concerns in the school identified by faculty. Faculty self-selected a team of choice and met weekly to look at data, address the concern and present findings. Through the Inquiry Teams, faculty worked collaboratively to review data (i.e. SAT or PSAT scores, prior Regents exams) to make informed decisions for students and the school.

The success of our school is not coincidental. In addition to its hardworking gifted students and a dedicated staff, the school is guided by a clear philosophical perspective that is translated into daily practice. From its earliest days, the founders of the school recognized the need for a clear, unified curriculum. They understood that for any school to be successful there has to be a body of knowledge that the students learn and master in all the academic disciplines. Working collaboratively, the teachers and administrators produced a sequenced, knowledge-rich curriculum.

DIVERSITY AT HSMSE

Our student body, in addition to being gifted, is also highly diverse. In May 2012, The New York Times published a study entitled: “A Portrait of Segregation in New York City’s Schools.” The study asserted that: “schools across the country have been going through a process of de facto resegregation. In New York, efforts over the years to reduce the segregation of schools have had little effect.” In contrast, HSMSE was identified as the most diverse school in New York City. According to the study’s author: “The Mathematics, Science and Engineering High School at City College is the [city’s] most diverse … (130 Asians, 75 blacks, 99 Hispanics and 101 whites).”


When you walk through the hallways of HSMSE you can witness the fruit of our diversity. You are not likely to encounter students of similar ethnicity congregating.

Diversity seems to be a matter of fact for our students; they do not dwell on it; they simply live it. In its first twelve
years, the school did not encounter incidents of ethnic tensions.

Unfortunately, among the city’s specialized high schools there has also been a trend that as schools become more academically successful they also become less diverse. Thus, I worry that we will now be seeing the beginning of this trend at HSMSE.

I chose to write this article because we cherish our diversity; it is an integral part of who we are. However, as the table below illustrates, we are seeing the beginning of a shift in the school’s demographics.

<table>
<thead>
<tr>
<th>Year</th>
<th>Asian</th>
<th>White</th>
<th>Black</th>
<th>Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2011</td>
<td>32%</td>
<td>25%</td>
<td>19%</td>
<td>24%</td>
</tr>
<tr>
<td>2011-2012</td>
<td>37%</td>
<td>25%</td>
<td>16%</td>
<td>21%</td>
</tr>
<tr>
<td>2012-2013</td>
<td>35%</td>
<td>28%</td>
<td>14%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Figure 1. Enrollment by ethnicity 2010-2013

Reaffirming Our Diversity

HSMSE has taken several major steps hoping to maintain the school’s diversity. Responding to various concerns, each of these initiatives has proven successful in our mission toward maintaining diversity.

Discovery Program

Discovery is a program developed by New York City’s Department of Education. Its aim is to give students who did not receive a score high enough for admission to one of the specialized high schools, a chance to participate in a summer program to qualify for a seat in one of the schools. Its original intent was to provide access to students of color.

“As stated in the State law, the Specialized High Schools may sponsor a Discovery Program to give disadvantaged students of demonstrated high potential an opportunity to participate in the Specialized High School Program. The Office of Student Enrollment will determine the Specialized High Schools sponsoring a Discovery Program. Students will be notified if they are eligible to apply.” (NYC Department of Education, 2013-2014 Specialized High Schools Student Handbook).

To be eligible, the student must:

1) have scored below and close to the lowest qualifying score on the SHSAT; eligible scores will vary from year to year and will be based on seat availability;

2) be certified as disadvantaged by his/her middle school according to the following criteria:

a. Attend a Title I school and be from a family whose total income is documented as meeting federal income eligibility guidelines established for school food services by the NYS Department of Agriculture, effective July 1, 2013; or

b. Be receiving assistance from the Human Resources Administration; or

c. Be a member of a family whose income is documented as being equivalent to or below Department of Social Services standards; or

d. Be a foster child or ward of the state; or

e. Initially have entered the United States within the last four years and live in a home in which the language customarily spoken is not English; and

3) be recommended by his/her local school as having high potential for the Specialized High School Program.

Those students who are successful in meeting the demands of the summer program will be granted an offer to the school sponsoring the Discovery Program. Those students who are not successful will attend the school to which they had previously been assigned. (NYC Department of Education, 2013-2014 Specialized High Schools Student Handbook).

HSMSE has participated in the Discovery Program for the past four years. Depending on the number of students who accept an offer, we open as many seats as possible since we have encountered success with the students and realized that the program helps maintain our diversity.

The program runs the summer following the exam, prior to entering high school. We host the program at HSMSE and make it a comprehensive program for students. Classes are taught by HSMSE faculty, students receive mentors, tutoring, school and campus tours and they get to know the environment. We get to know students by name and by face.

Once enrolled in our HSMSE, we track the students’ progress regularly and when necessary we provide additional support throughout their tenure at HSMSE. Our data suggests that our “Discovery” students do well: 98% of Discovery students come in at a level 3 or 4. They are all on track for graduation with their cohort.

Middle School Initiative

With great concern after reviewing the worrying trend that affect our diversity, I decided to launch my own initiative, in the Spring of 2014. I called it the STEM Middle School Initiative (MSI). The roll out consisted of several components. I held a guidance counselors breakfast for my district (we currently have only seven students
in the school’s zip code that attends HSMSE). The breakfast was a way to bring colleagues together to showcase the school as well as to discuss the program and answer any questions or concerns. We conducted a parent workshop at HSMSE to explain the program and have parents understand the commitment level expected of all participants. Our lead math teacher and Assistant Principal visited local middle schools to generate more student interest. Emails were sent to Superintendents, Principals and Guidance Counselors in the area announcing the launch of the STEM MSI Program with an explanation of the program.

The program seeks to partner with schools in our surrounding area. Our goal is not only to introduce higher level content and prepare students for the Specialized High School Exam (SHSAT), but also to introduce students, specifically, to the STEM disciplines through a set of modules taught by our own faculty.

The program is designed to begin working with a select group of students in the sixth grade and continue the work through the eighth grade as they gain knowledge and are better prepared for the specialized high schools exam. Students attend the program twice a week, on Saturdays from 9:30 am -1:30 pm and on Tuesdays, from 4:00-6:00 pm. On Saturday we also serve the students both breakfast and lunch.; In the Saturday session, our instructors lay foundation in both mathematics and ELA, filling the gaps. After providing this scaffolding, we plan on transitioning to more rigorous and intensive test prep sessions. On Tuesdays, through a set of modules, students are introduced to subjects in STEM through instruction and hands-on activity (i.e. robotics, math research, engineering concepts). Additionally, teaching our STEM MSI students will go beyond the borders of the classroom; for example visiting THE New York State Structural Biology Center and the North River Waste Water Treatment Plant, both located very close to HSMSE.

The selection criteria include several components that go beyond scores on State exams. We look for the following: the students must attend a middle school in our school district or a neighboring one; be at the top 15% of students in the school and the top 10% in science and mathematics; a teacher recommendation; an essay, and standardized test scores of level 3 in math and level 3 in reading (due to the responses from school leaders indicating that the rubric for standardized exams have changed, we now accept students with a high level 2).

As part of our school’s Service Learning Projects, we anticipate that HSMSE students will play an active role in the process serving as mentors and tutors during the sessions to receive community service credit. We have also partnered with middle school principals for our students to serve as tutors for students in their schools during after-school programs.

The middle school initiative is a blueprint in the making, striving towards equipping students with the tools they need to be academically successful and ultimately to pass the SHSAT.

**THE DILEMMA**

Maintaining diversity is very important to me. Nevertheless, as we prepare students for high school, the STEM fields, college, and beyond, I am reminded of the dilemma that students of color are underrepresented in the nation’s top secondary schools, colleges and universities.

There are many questions that still remain, which cannot necessarily be answered absolute, due to the number of variables that must be considered, but we should still ask and never stop seeking answers.

As I think about the “diversity” issue for our school, I am left with several questions:

- Should we focus our energies on prepping students of color for the admissions exam or preparing all students earlier?
- Why is the disproportionate number of students of color in top schools still happening?
- Will some students always be a victim of their neighborhood and/or circumstances?
- Is it that some students don’t have the acumen or is it access?
- What can I do to make a difference?
- Where does this leave our school? Our city? Our nation?

Crystal Bonds is Principal at High School for Math, Science and Engineering at City College, New York, NY
Developing STEM Talent Among Diverse Learners

by Julia Link Roberts, Ph.D.

Developing talent in science, technology, engineering, and mathematics (STEM) is important for individuals as well as for the well-being of our country. It is essential to tap interest early in both boys and girls, children from all socio-economic backgrounds, those who have recently come to the U.S. and for whom English is not yet their first language, and young people who represent all racial and ethnic groups. Nothing in a child’s background should put up barriers to cultivating interest in STEM subjects, developing an interest into a passion, following that interest into a successful college experience complete with a degree, and then pursuing a STEM career. Opportunities that spark interests and develop talents need to be available, and young people need to know about opportunities as an opportunity is not a real opportunity unless one knows about it. Advocates must follow-up and locate financial support to ensure that the opportunity is a real possibility to all who qualify.

Currently, the U.S. is not stacking up in educating students in STEM disciplines. “America lags in providing top-level schooling in STEM fields..., and this may jeopardize our future economic growth, job creation, and international competitiveness” (Smarick, 2013, p. 12). International assessments of student performance, including the Program for International Student Assessment (PISA), show that students in other countries are outperforming U.S. students, especially in the STEM fields. These are the fields that lead to innovation and offer opportunities for high paying positions. “But, if the country is to remain competitive internationally, as well as facilitate individual opportunity and social mobility, we must face the reality that cultivating tomorrow’s intellectual and scientific leaders is a key part of the education system’s function” (Finn, 2014, p. 61).

Currently, far too many of America’s best and brightest young men and women go unrecognized and underdeveloped, and, thus, fail to reach their full potential. This represents a loss for both the individual and society. The Nation needs “STEM innovators”--those individuals who have developed the expertise to become leading STEM professionals and perhaps the creators of significant breakthroughs or advances in scientific and technological understanding. (National Science Board, p. 1)

In Mind the (Other) Gap: The Growing Excellence Gap in K-12 Education, Plucker, Burroughs, and Song (2010) introduced the term Excellence Gap to describe the growing gap between the percentages of children in diverse groups and other children scoring at advanced levels in mathematics and language arts. The Achievement Gap has highlighted differences between groups of children scoring at the level of proficiency, and the Excellence Gap does the same thing but uses the advanced level of achievement as the mark of excellence. They found that few children from low-income families and few Hispanic and Black young people scored at the advanced levels on the National Assessment of Educational Progress (NAEP). The Excellence Gap also is evident in science scores (Burroughs, 2012). The Excellence Gap is so large as to be alarming; and, if something is not done about closing the Excellence Gap, it will not happen in the lifetime of current citizens. Plucker, Hardesty, and Burroughs (2013) concluded Talent on the Sidelines: Excellence Gaps and America’s Persistent Talent Underclass with this stark statement.

In an age of increasing global competitiveness, it is somewhat harrowing to imagine a future in which the largest,
fastest-growing segments of our K-12 student population have almost no students performing at advanced levels academically. In many states, including many of our largest, this is already the reality. (p. 29)

What strategies can change the current situation? What can you as individuals and schools do to ensure that children and young people from diverse backgrounds are prepared to be successful at STEM careers?

1. **Remove barriers to children being recognized as having the potential to perform at advanced levels.** The challenge to individuals and to schools is to remedy the problem by removing barriers to advanced learning. Advocate for policies at the school and district levels that allow children to progress based on their readiness to learn more advanced concepts and skills rather than making those decisions based on age.

2. **Foster early interest in STEM topics among all children.** Work with others to offer minds-on, hands-on learning experiences for children and young people. Volunteer in classrooms and in organizations outside of school that engage children in learning. Individuals can pique interest also by sharing stories about their passion for a particular STEM interest.

3. **Provide support for young people who are interested in pursuing STEM topics much like a coach does to ensure continuing interest in a sport.** Educators and older students can work with children and young people in various ways. Perhaps they can lend their support so a school can have a FIRST Lego Robotics team, a Future Problem-Solving team, a Odyssey of the Mind team, or any other team that encourages creative and critical thinking, problem solving, and interest in STEM subjects.

4. **Prepare young people to pursue academic work that is challenging as they develop study skills, persistence, and advanced academic skills.** It is no favor to a young person to have an excellent grade-point-average in easy classes but not have experiences to ensure readiness for success in post-secondary study. Talk with students and parents about the preparation needed to graduate from a college or university with a STEM major. Having a rigorous course of study is the necessary start for a young person planning to pursue a STEM career, and that challenge needs to be built into elementary, middle, and high school learning experiences.

“The failure of the U.S. educational system to properly nurture students from disadvantaged backgrounds may be an important contributor to the low proportion of U.S. students entering science, technology, engineering, and mathematics (STEM) fields” (Plucker, Hardey, & Burroughs, p. 3). Specialized secondary schools can play a major role in reversing the current situation and in addressing the need for young people, including those from diverse backgrounds, to be prepared to pursue STEM careers. What will your part be in making this change happen?

**REFERENCES**


Julia Link Roberts, Ph.D., is Mahurin Professor of Gifted Studies, Western Kentucky University and Executive Director, The Center for Gifted Studies and the Carol Martin Gatton Academy of Mathematics and Science in Kentucky
Increasing Interest of Young Women in Engineering

by Diane Hinterlong, Branson Lawrence & Purva DeVol, Ed.D.

INTRODUCTION

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 in grades 10 through 12 in its advanced, residential college preparatory program. IMSA also 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.

Each year, IMSA enrolls approximately 225 students composed of nearly equal numbers of male and female students. Students are required to complete a core science program consisting of four courses in chemistry, physics, biology and scientific research during their sophomore year. Juniors and seniors must complete a minimum of four electives in science over the next two years. Students may elect to fulfill their elective requirements by completing any courses offered in the science program.

In the fall of 2004, engineering was first offered as a physics elective to upperclassmen. When the course was first offered, female and male student enrollment was approximately equal. Over the first few years that the course was offered, however, the percentage of female students enrolled in the course dropped significantly. Active recruitment of female students by IMSA instructors was the only factor preventing the course from becoming an all male course.

The growing disparity in enrollment of females and males in IMSA’s engineering course prompted further inquiry, beginning with a review of relevant literature exploring trends in physics/engineering enrollment patterns. Following the literature review, a quantitative analysis was initiated to examine the assumption that the same trend of disparity in enrollment between females and males existed in other physics courses. Based on this data, information to provide insight into the reasons for the disparity was elicited through focus groups and surveys among IMSA students. Finally, action steps to proactively address the disparity were identified and implemented.


Enrollment in IMSA physics electives was analyzed for every student from the 2003-04 academic year through the
The lowest percentage of female enrollment occurred in engineering, where female students constituted 29% of the enrollment over the last six academic years.

Gender differences were then analyzed by ethnicity. Table 2 shows the female and male students who took physics electives prior to graduation, categorized by ethnicity.

Significantly fewer African-American females enrolled in electronics (7 out of 64, or 11%) compared to African American males (19 out of 33, 58%). The same is true for Latinas in calculus-based physics (4 of 34, 12%), compared to Latinos (12 of 33, 36%). Males of all ethnic groups took calculus-based physics at a greater number and percentage than their female peers, but the gap was significantly less for Asians. 45% (118 of 262) of Asian females took Calculus-Based Physics, compared with 70% of Asian males (175 of 251).

### Table 1. Difference between female and male enrollment in physics electives

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Advanced Physics</td>
<td>60% F</td>
<td>59% F</td>
<td>60% F</td>
<td>47% F</td>
<td>53% F</td>
<td>51% F</td>
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<td>54% M</td>
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<td></td>
<td>(60, 40)</td>
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<td>(43, 29)</td>
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<td>(69, 62)</td>
<td>(32, 31)</td>
<td>(39, 39)</td>
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<td></td>
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<tr>
<td>Modern Physics</td>
<td>49% F</td>
<td>39% F</td>
<td>36% F</td>
<td>44% F</td>
<td>37% F</td>
<td>45% F</td>
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<td>203 F</td>
<td>39% M</td>
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<tr>
<td></td>
<td>(51 M)</td>
<td>(61 M)</td>
<td>(33, 59)</td>
<td>(35, 44)</td>
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<td>(19, 20)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calc-Based Physics</td>
<td>35% F</td>
<td>31% F</td>
<td>41% F</td>
<td>32% F</td>
<td>30% F</td>
<td>29% F</td>
<td>40% F</td>
<td>202 F</td>
<td>34% M</td>
</tr>
<tr>
<td></td>
<td>(65 M)</td>
<td>(69 M)</td>
<td>(59 M)</td>
<td>(68 M)</td>
<td>(70 M)</td>
<td>(71 M)</td>
<td>(60 M)</td>
<td>(392 M)</td>
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<td>(39, 56)</td>
<td>(31, 65)</td>
<td>(22, 51)</td>
<td>(23, 57)</td>
<td>(25, 37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>30% F</td>
<td>40% F</td>
<td>34% F</td>
<td>31% F</td>
<td>36% F</td>
<td>32% F</td>
<td>32% F</td>
<td>103 F</td>
<td>34% M</td>
</tr>
<tr>
<td></td>
<td>(70 M)</td>
<td>(60 M)</td>
<td>(66 M)</td>
<td>(69 M)</td>
<td>(64 M)</td>
<td>(68 M)</td>
<td>(68 M)</td>
<td>(202 M)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(21, 49)</td>
<td>(23, 34)</td>
<td>(12, 23)</td>
<td>(11, 25)</td>
<td>(13, 23)</td>
<td>(12, 25)</td>
<td>(11, 23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>*</td>
<td>43% F</td>
<td>41% F</td>
<td>30% F</td>
<td>28% F</td>
<td>19% F</td>
<td>25% F</td>
<td>50 F</td>
<td>29% M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(57 M)</td>
<td>(59 M)</td>
<td>(70 M)</td>
<td>(72 M)</td>
<td>(81 M)</td>
<td>(75 M)</td>
<td>(120 M)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9, 12)</td>
<td>(9, 13)</td>
<td>(8, 19)</td>
<td>(10, 26)</td>
<td>(7, 29)</td>
<td>(7, 21)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Engineering was not offered until the 2004-05 academic year
Table 2. Number, ethnicity and gender of IMSA graduates of 2004-2010 who took each physics elective

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Gender of 2004-2010 graduates</th>
<th># who took Advanced Physics</th>
<th># who took Modern Physics</th>
<th># who took Calc-Based Physics</th>
<th># who took Electronics</th>
<th># who took Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asians</td>
<td>262 F, 251 M</td>
<td>117 F, 75 M</td>
<td>59 F, 102 M</td>
<td>118 F, 175 M</td>
<td>18 F, 43 M</td>
<td>11 F, 16 M</td>
</tr>
<tr>
<td>Latinos</td>
<td>34 F, 33 M</td>
<td>14 F, 28 M</td>
<td>13 F, 12 M</td>
<td>4 F, 12 M</td>
<td>11 F, 15 M</td>
<td>4 F, 13 M</td>
</tr>
<tr>
<td>Caucasians</td>
<td>302 F, 312 M</td>
<td>147 F, 146 M</td>
<td>103 F, 166 M</td>
<td>72 F, 216 M</td>
<td>58 F, 109 M</td>
<td>29 F, 77 M</td>
</tr>
<tr>
<td>Multiracial</td>
<td>38 F, 25 M</td>
<td>18 F, 16 M</td>
<td>10 F, 13 M</td>
<td>5 F, 12 M</td>
<td>7 F, 13 M</td>
<td>3 F, 5 M</td>
</tr>
<tr>
<td>Ethnicity not given</td>
<td>12 F, 12 M</td>
<td>7 F, 10 M</td>
<td>3 F, 7 M</td>
<td>4 F, 9 M</td>
<td>1 F, 3 M</td>
<td>0 F, 4 M</td>
</tr>
</tbody>
</table>

Table 3. Graduates from 2004-2010 who earned a C or lower in each physics elective, grouped by ethnicity

<table>
<thead>
<tr>
<th>Physics Elective</th>
<th>African Americans with C or below</th>
<th>Latinos with C or below</th>
<th>Multiracial with C or below</th>
<th>Asians with C or below</th>
<th>Caucasians with C or below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Physics</td>
<td>15% (9/59)</td>
<td>19% (8/42)</td>
<td>*</td>
<td>6% (12/192)</td>
<td>9% (27/293)</td>
</tr>
<tr>
<td>Modern Physics</td>
<td>24% (7/29)</td>
<td>24% (6/25)</td>
<td>17% (4/23)</td>
<td>10% (16/161)</td>
<td>7% (19/269)</td>
</tr>
<tr>
<td>Calc-Based Physics</td>
<td>44% (7/16)</td>
<td>44% (7/16)</td>
<td>*</td>
<td>14% (41/293)</td>
<td>12% (34/288)</td>
</tr>
<tr>
<td>Electronics</td>
<td>15% (4/26)</td>
<td>23% (6/26)</td>
<td>20% (4/20)</td>
<td>*</td>
<td>8% (14/167)</td>
</tr>
</tbody>
</table>

*Not reported because fewer than 4 students of this ethnicity earned a C or lower in this class. Engineering was excluded because fewer than 4 students of every ethnicity earned a C or below.
B. Grade Differences:
With differences in female and male enrollment for all ethnic groups, the next step was to examine the academic grades earned by the students in the physics electives. The percentage of students, by ethnicity, who earned a C or lower in each physics elective was determined. Table 3 presents the data for the last seven academic years. The only elective in which over 10% of students in each group earned a C was calculus-based physics. Of particular concern was that at least 19% of Latino students earned a C in each of the four electives (ranging from 19% in advanced physics to 44% of Latino students earning a C in calculus-based physics).

Qualitative Analysis: Focus Groups to Examine Students’ Perceptions
The above analysis of data served as a basis for selection of questions and participants for small focus groups in the spring semester of 2009, conducted by Dr. Margery Osborne from the University of Illinois at Urbana-Champaign (UIUC). Although there were a small number of participants, 14, the focus groups revealed stark differences between males and females regarding their interest in physics.

Male students indicated that they like constructing physical models and problem solving and they were excited about projects. They were not worried about grades and saw physics as fun and connected to their life experiences. Male students further indicated that they like physics because it was not abstract. Interestingly, female students indicated just the opposite; they saw physics as abstract. Female students like physics because they felt they were good at it and earned good grades. Their reasons for liking physics, such as positive teacher relationships, were more personal than those provided by the male students. Table 4 below summarizes their responses:

Table 4. Why students like physics

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Abstract</td>
<td>Abstract</td>
</tr>
<tr>
<td>Disregard Grades</td>
<td>Good Grades</td>
</tr>
<tr>
<td>Experiential Connections</td>
<td>Personal</td>
</tr>
<tr>
<td>Building</td>
<td>Good at it</td>
</tr>
<tr>
<td>Problem Solving</td>
<td></td>
</tr>
<tr>
<td>Projects</td>
<td></td>
</tr>
<tr>
<td>Fun</td>
<td></td>
</tr>
</tbody>
</table>

The disparate viewpoints of the genders held regardless of the students’ grade level, ethnicity and academic achievement in physics electives.

ACTION STEPS
The quantitative and qualitative data served as the foundation for creating action plans to reduce the disparities in enrollment and achievement as summarized below.

1. Class Changes: Advanced Physics has typically seen a decline in enrollment from first semester (Applied Mechanics) to the second semester (Sound and Light). Beginning the fall semester of 2010, the two semesters were switched so that the Advanced Physics: Sound and Light class was offered in the fall semester and the Advanced Physics: Mechanics class was offered in the spring semester. Since the introductory course, Scientific Inquiries: Physics, focused on mechanics, the goal of switching the sequence of the advanced courses was to offer new options in physics for students after completing the core rather than expanding knowledge of mechanics. In making this option of new topics available to students after completing the core, the hope was that students might be more inclined to stay enrolled in physics electives.

More recently, Applied Mechanics has been eliminated as a physics elective and students choosing to continue study of classical mechanics have been encouraged to enroll in Calculus-Based Physics: Mechanics. In addition, Sound and Light is now offered both semesters.

Other changes that occurred were in the physics class required for all sophomores, Scientific Inquiries: Physics. It is important to note that the changes to Scientific Inquiries: Physics were not a direct result of this research nor were they made to solely address differences in enrollment and achievement of females and underrepresented minorities. In 2009-10, the teachers of Scientific Inquiries: Physics made changes to the course focused on improved student learning. These changes included allowing students to make revisions on their assessments, reordering topics to promote increased student engagement, and paying attention to the grouping of students in these classes. As these changes benefit the learning of all students in physics, the expectation is that the gap in enrollment and academic achievement in physics electives will decrease for females and underrepresented minorities. The teachers of Scientific Inquiries: Physics incorporated changes to make the course proficiency-based and to allow more autonomy in working through concepts in order to support more personalization for students starting in the 2010-11 school year.
2. **Alumni Connections:** In the spring semester of 2010, a female alumni event was piloted to expose current students to successful female alumni currently working in STEM related fields. The goal was to increase interest of females to pursue STEM classes and careers. Six female IMSA alumni who had completed degrees in the physical sciences were invited to speak with IMSA students about their interest in STEM fields and their career choices and experiences. The event was created to allow for open dialogue with students in a casual setting. About 20 students attended the event, two of whom were male students. Approximately 45-50% of the students were African Americans. Although a small event, this may be replicated on a larger scale in future years.

3. **Elective Choices:** Students clearly influence one another’s choices when selecting electives as affirmed through a survey eliciting student feedback on their elective choices. As the number of females enrolled in Engineering decreased, so did the number of females influencing peers to sign up for this physics elective. Several actions were taken to proactively inform students about the Engineering course. During a school elective fair, two videos were used to help inform students about the course. One video included interviews with two female students currently enrolled in the class; the other video captured some of the exciting projects students engaged in during the scope of the course.

In addition, in the fall of semester of 2010, juniors and seniors enrolled in the course invited in teams of sophomores for an engineering competition. There were 6 teams in total that participated in the “Cardboard Boat Race” in September 2010. Each team was voluntarily formed and composed of two males and two females. With the assistance of junior and senior students enrolled in the fall 2010 semester of Engineering, the sophomore teams created boats from a fixed amount of cardboard, and then raced them across a campus pool for prizes. While learning engineering principles in a team setting, the goal was to excite more females and underrepresented students to enroll in Engineering as a junior or senior.

4. **Project Choices:** The mission of IMSA, the world’s leading teaching and learning laboratory for imagination and inquiry, is to ignite and nurture creative, ethical, scientific minds that advance the human condition, through a system distinguished by profound questions, collaborative relationships, personalized experiential learning, global networking, generative use of technology and pioneering outreach. Each year, students enrolled in Engineering were required to propose an innovative project. Peer feedback on projects helped refine the projects and collaborative teams worked on projects selected to move from the idea phase into a prototype phase. In the first years the course was offered, students were given significant latitude in selecting a project. As the course evolved, more structure was embedded into the projects with a focus on energy-related projects one year followed by the current requirement to align projects with the IMSA mission, i.e., projects were required to “advance the human condition.” Examples of student projects include keyboards for
individuals with limited use of hands or arms and swimming caps to aid blind swimmers. Based on survey feedback from students, alignment of projects to the mission was received positively especially by the female students. They were more excited and engaged by projects with this human factor embedded into the scope of the projects.

RESULTS/NEXT STEPS:

Although it is difficult to ascertain the influence of each individual action step, it is clear that something has made a difference. The downward trend in female enrollment in the Engineering course that originally sparked this investigation has not only stopped but female enrollment in the course has increased as noted in the chart below.

Moving forward, enrollment trends will continue to be monitored. The teachers of the introductory core course will evaluate the effectiveness of moving to a proficiency-based model in this course. In addition, the data presented here regarding grades, gender and ethnicity raise more questions to be considered in a future study.
Case Study of a Successful Educational Partnership: University of Illinois at Urbana-Champaign and the Illinois Mathematics and Science Academy

by Dave DeVol, Ph.D.

INTRODUCTION

This article describes partnerships between an NCSSSMST member institution and a research university and the use of student-generated survey data as a means of both professional self-reflection and asking further questions. As a chemist, I have been trained to write in the style of scientists, and in fact I teach a course at the Illinois Mathematics and Science Academy on the methods of science and scientific writing. This article is intentionally not written in a scientific style; rather is written to convey a story of how a partnership between institutions naturally progressed into my current area of research into motivational issues of gifted students.

BACKGROUND

When the Illinois Mathematics and Science Academy (IMSA) was founded in 1985, the state of Illinois charged IMSA with two mandates:

• Legislative Mandate 1: “The primary role of the Academy shall be to offer a uniquely challenging education for students talented in the areas of mathematics and science.”

• Legislative Mandate 2: “The Academy shall also carry a responsibility to stimulate further excellence for all Illinois schools in mathematics and science.”

The first mandate is fulfilled through IMSA’s residential academy for talented high school students, and the second is fulfilled through outreach programs that serve students and educators throughout the state.

In keeping with the second legislative mandate, a partnership between the University of Illinois at Urbana-Champaign (UIUC) and IMSA was formed. At that time I, along with the other Advanced Chemistry (Ad Chem) teachers, were contemplating significant curriculum changes in Ad Chem. Those changes were proposed to make the Ad Chem curriculum more laboratory- and inquiry-based, and less like an AP Chemistry preparation course. A laboratory and inquiry based curriculum fits well within IMSA’s philosophy and aligns with IMSA’s Standards of Significant Learning (SSLs), (https://www3.imsa.edu/learning/standards/ssl.php). The IMSA SSLs are a set of standards that value constructivism and students “learning how to learn.” They are not content-based but process-based. While valuing the SSLs is important at IMSA, there is no denying that students and parents value AP scores. Thus, when I spoke with IMSA’s principal in the summer of 2008 about modifying the Ad Chem curriculum, he gave his support with the caveat that we fully explain the changes and the rationale to both parents and students (which we subsequently did at IMSA’s “Parent Day”).

At a meeting in Champaign-Urbana between IMSA and UIUC faculty and staff, I met a doctoral student in the UIUC College of Education. As a former chemistry teacher at an academy in Singapore, she was interested in science curriculum, and intended to make science curriculum the focus of her doctoral dissertation. She was intrigued by the proposed curriculum changes to Ad Chem, and
arrangements were made for her to make the study of our curriculum changes the focus of her Ph.D. thesis.

The curriculum changes to Ad Chem were made by the IMSA chemistry team during the summer of 2009, and implemented during the 2009-2010 school year. Additional changes were made in the summer of 2010, with a particular focus on writing pre- and post-lab questions that would allow laboratory experiences to drive the curriculum. The UIUC doctoral student conducted her research at IMSA during the spring and fall of 2009, and the spring of 2010. Her research consisted of observing Ad Chem classes twice per week, surveying students each of the three semesters, and interviewing students, the Ad Chem teachers, IMSA parents, and IMSA administrators. She completed her Ph.D. work in 2011, and has subsequently returned to Singapore and holds a position in the National Institute of Education. A copy of her Ph.D. thesis is in the IMSA repository for scholarly work (http://digitalcommons.imsa.edu/).

RESULTS

Over the past three years, the Ad Chem teachers have collected and analyzed data on student views of the revised version of the Ad Chem course. Students were asked eight questions about the course and responded on a 5 point Likert scale (see Figure 1). Results overall have been very positive for learning attributes that we value and that align with IMSA’s Standards of Significant Learning, namely thinking and analyzing, making connections, constructivism, and classroom environment. In education, we walk a “tightrope” of how much direct instruction to provide versus how much to allow students to learn via inquiry, laboratory experiences, reading, and collaborative work. For the prompt “Do you wish the teacher would explain more,” the average student response was very close to three for all three years, indicating that we have found a reasonable balance between direct instruction and other modes of teaching.

Approximately 70 to 75 percent of IMSA students take Advanced Chemistry, making it the highest enrolled elective in the academy. It had been speculated that the reason for this is the requirement for one year of chemistry in order to apply to most colleges and universities; and this requirement is not met by the core sophomore chemistry class at IMSA, which is a one semester course. Therefore, students were not only surveyed on their views of the curriculum, but also on their motivation to enroll in the course and their motivation to work in the course. As shown in Figure 2, students do sign up for Advanced Chemistry because they feel they need it for college. This response, however, was chosen less frequently than other options, such as “I heard it was a good course” and “I really like chemistry.” I was intrigued that very few students indicated that they took the course because their parents thought they should.

In terms of what motivates students to work in Advanced Chemistry, students did choose their grade as the number one motivational factor. Other factors were also important to students, however, such as “I really like learning” and “I really like chemistry” (see Figure 3). This is not surprising, as it indicates a combination of extrinsic and intrinsic motivational factors, and it has led me toward a deeper and longer-term inquiry into motivation across the sciences.

Finally, a couple of observations are important. It is noteworthy that the patterns of student responses over the three years are quite similar, which indicates that it is likely that students’ responses are accurately capturing their attitudes towards the course and the sources of motivation for the course. In addition, it is important to note that the survey was not administered to Advanced Chemistry students prior to our implemented curriculum changes, so there is no baseline for comparison. Therefore we cannot determine what student responses would have been prior to curriculum changes. The chemistry team at IMSA does not claim to have created a better course, only a course that is somewhat different than it had been. Advanced Chemistry was a very good course, developed by experienced and excellent faculty, prior to curriculum changes being implemented.
Throughout this partnership based on mutual inquiry between our two institutions, much was learned. The difficulties of making curriculum changes that put a greater emphasis on laboratory experiences and less on content are documented in the graduate student’s doctoral thesis. I also learned a great deal by reflecting on student responses in the course surveys, and was especially interested in the combination of extrinsic and intrinsic motivational factors that students exhibited and which were quite consistent over a three-year period. That interest has now led to a more scientific approach to studying motivational constructs of IMSA students using a validated research instrument. In essence, the story unfolded like research often does, one set of observations leads to a new set of questions.

IMSA holds a unique place within the state of Illinois, and strives to be a laboratory for teaching and learning. The term laboratory, in this context, does not refer to a chemistry, physics, or biology laboratory. It refers to the academy as a whole, and an attempt to create a constructivist learning environment for students, where learning takes place in context. It refers to an attempt to try new things, to welcome success and learn from mistakes; to take risks. IMSA was indeed the UIUC graduate students’, the Ad Chem teacher’s, and the IMSA student’s laboratory throughout this process.

Figure 1.

Student responses to survey questions regarding the revised Advanced Chemistry curriculum at IMSA over a three year period (2010-2012). The Likert scale was as follows: 1= not at all; 5= definitely. In 2010, 151 students were surveyed; in 2011, 137 students were surveyed; in 2012, 133 students were surveyed. The survey prompts were as follows:

1 – Do you feel Ad Chem is a course that fits IMSA’s “philosophy” of learning and teaching?
2 – Compared to other IMSA courses, does Ad Chem make you think and analyze concepts and ideas?
3 – Have you made connections to other disciplines in Ad Chem?
4 – Do you feel you are “constructing” an understanding of chemistry by integrating ideas from lab experiences, the textbook, and classroom discussions?
5 – Do you feel that the teacher is providing a classroom environment that helps you “construct” an understanding of chemistry?
6 – Do you wish the teacher would explain more?
7 – Are the supplemental, teacher-written materials on Moodle helpful?
8 – Do you feel Ad Chem is a good IMSA course?

Figure 2.

Student responses to the prompt: What was your motivation to sign up for Ad Chem? (Circle all that apply, fill in other if appropriate). Cumulative percent adds up to greater than 100% because students could choose multiple motivations. Motivational prompts were as follows:

1 – Heard it was a good course
2 – Felt I needed it for college
3 – My parents thought I should take it
4 – Everyone seems to take it
5 – I really like chemistry
6 – Other
Figure 3.

Student responses to the prompt: What is your motivation to work at Ad Chem? (Circle all that apply, fill in other if appropriate). Cumulative percent adds up to greater than 100% because students could choose multiple motivations. Motivational prompts were as follows:

1 – My grade
2 – I really like chemistry
3 – I really like learning
4 – My parents expect good grades
5 – Other

ACKNOWLEDGEMENTS:
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Dr. Margery Osborne – Dr. Teo’s Ph.D. advisor at the University of Illinois
Dr. Tang Wee Teo – UIUC doctoral student
Quick Start Guide: Writing a Best Practices Article

by Jonathan Ian Creamer, Ph.D.

One of the many strengths of NCSSSMST institutions is the gifted, innovative and hard-working educators of our member schools. The courses, projects and lessons taught by NCSSSMST educators reflect the best practices in STEM education, and one of our organizational aims is to disseminate these best instructional practices among member schools, as well as to educators at other institutions. The *NCSSSMST Journal* is a perfect place to publish and share our best practices in teaching and learning. In the next few issues of the *NCSSSMST Journal*, we plan to highlight the innovative practices at our member schools, and we invite you to submit examples of effective practices from your experience as an educator.

Given our busy schedules, however, writing up teaching methodologies as a best practices article could seem daunting, but we educators typically already have the critical pieces of a best practice article already written up – lesson plans, presentations, handouts, etc. In order to assist you in the development of an article for publication in a forthcoming issue of the *NCSSSMST Journal*, we have developed a *Quick Start Guide* that will help you organize your thoughts and materials to share with NCSSSMST colleagues.

Table 1 below outlines the typical structure of a best practices article, along with suggested content for each section.

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<tr>
<td>Introduction/Background</td>
<td>What problem is this best practice addressing? Justify the importance of addressing this problem using whatever evidence is available.</td>
</tr>
<tr>
<td>Results &amp; Discussion</td>
<td>Assess the outcomes (competition/assessment/survey results, improvements in concept understanding, engagement, etc.). How do you know this works?</td>
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<tr>
<td>Unique/Beneficial Features</td>
<td>How is this different/better from related best practices? What makes this a best practice?</td>
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<td>Issues &amp; Future Plans</td>
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Table 1.  Suggested organization for NCSSSMST best practices article

**HELPFUL HINTS:**

- Use your established resources (conference presentation, lesson plans, class materials, etc.)
- Refer to previous versions of the NCSSSMST journal for examples of published articles
- Get a colleague to read through the draft article to see if it gets the salient points across and to make suggestions/edits
Formatting & Manuscript Submission:

- Submit your manuscript as a Word document (.doc). Figures, photos, and other graphics should be embedded in the Word document AND also submitted as separate files to be used during the layout process.
- All manuscripts should be double spaced, with one-inch margins, and numbered pages. Use a single 12-point font throughout the manuscript. Avoid extra formatting as this delays final layout.
- Once you have drafted the manuscript, review and edit so that it is no more than 2,000 words. References, captions, and figures are not included in the word count.
- A 200-word abstract should accompany your submission.
- References and resources lists should be alphabetized by author and done in APA style.
- Authors are responsible for permissions for the use of any graphics or photos and for the accuracy of permissions, citations, quotations, figures, and facts used in their manuscripts.

Submit the manuscript document, along with all additional graphics files, to ncssmsteditor@gmail.com.

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Stuyvesant High School
The Bronx High School of Science
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Ohio
Hathaway Brown School
Oklahoma
Oklahoma School of Science and Mathematics
Pennsylvania
Downingtown STEM Academy
Pittsburgh Science & Technology Academy
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South Carolina Governor’s School for Science and Mathematics
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Tennessee
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SUCCESS Academy at Dixie State University - DSU
SUCCESS Academy at Southern Utah University - SUU

Vermont
Essex High School

Virginia
Central Virginia Governor's School for Science and Technology
Chesapeake Bay Governor's School
Governor's School @ Innovation Park
Health Sciences Academy Bayside High School
LCPS Academy of Science
New Horizons Governor's School for Science and Technology
Roanoke Valley Governor's School for Science and Technology
Shenandoah Valley Governors School
Southwest Virginia Governor's School
The Math & Science High School at Clover Hill
The Mathematics & Science Academy
Thomas Jefferson High School for Science and Technology
Virginia STEAM Academy

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Camas Math, Science, Technology Magnet Program

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