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Theme: "Innovations in Gender and STEM Education"

Introduction

Few issues raise greater educational concern than the need to improve K-12 outcomes in mathematics and science in the United States. The issue is seen as a matter of national security and competitiveness in a twenty-first century global economy where a primary American advantage has been our superior science and technology. This position is in jeopardy due to the rise of nations such as China, India, and Brazil which are investing heavily in education. Increasing the participation and achievement of girls in math and science is a critical factor in improving America's educational performance.

Reflecting the focus of ACI's Center for Success in High-Need Schools on improving the education of girls in math and science, this issue of the journal features a Lake Forest College-Waukegan Schools partnership exploring math, science, and gender in the middle school classroom. The issue also contains articles reporting on impacts of differentiated instruction on gender performance, gender equity in the classroom, and the relationship between poverty and low performing schools.

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Publisher's Column, *by Jan Fitzsimmons, Ph.D.*

I owe my love for science to my sixth grade teacher Mrs. Drafahl. To her small classroom in a small town surrounded by farms, she brought Bunsen burners, an array of tubes and beakers, and an extraordinary passion for science. Day after day, she inspired us to be curious and thoughtful about everything around us. For Christmas that year, she gave me and each of my classmates a test tube. I also begged my parents for a chemistry lab, which, to my surprise, did appear under our holiday tree. Every day during that winter break, I worked enthusiastically on experiments — testing various liquids with litmus paper, burning and bubbling all kinds of concoctions in test tubes, and noting their smell and appearance in my lab book. Mrs. Drafahl's science classes generated a sense of wonder, discovery, and curiosity that ignited my own passion for science.

I carried this passion into junior high and high school where, I have to admit, the boys were encouraged to do all of the fun things like dissecting animals! Nevertheless, I was ready to go to college and pursue a degree in medical technology until I shadowed a technologist at a hospital. It wasn't at all what I expected. It seemed a very lonely occupation for a young woman, and I began to think about how I really wanted to spend my time.

Unfortunately, too many women appear to have similar stories about missed careers in science, technology, engineering, and mathematics – the STEM fields. In 2007, the Associated Colleges of Illinois' (ACI) Center for Success in High-Need Schools launched a study to improve mathematics and science proficiencies of in-service teachers through a systemic response to two interrelated problems: the growing shortage of teachers equipped to nurture the math and science interests of minority and low-income girls attending high-need K-12 schools and the concomitant shortage of female professionals in STEM fields. This collaborative project enlisted six ACI member colleges and universities and their high-need school partners throughout Illinois to: 1) transform teacher education curricula to integrate gender-specific content and pedagogy to assure that middle grade girls in high-need schools had a rich, engaging, and supportive experience in the study of math and science that would ignite their interest and curiosity, further their knowledge and application of scientific and mathematical concepts, and generate an interest in pursuing further math and science study and ; and 2) offer professional development to math and science teachers in partner high-need school districts.

To that end, in the first two years of its STEM initiative, ACI's Center engaged 34 faculty and 32 in-service teachers, who have an impact on 2,500 students. Since its inception, the project has built a cadre of highly qualified teachers who can effectively mentor new teachers and motivate more minority and low-income girls to persist in studying math and science in middle school, high school, and college. It also has supported educational improvements that benefited both individual learners and the larger enterprise of STEM teaching and learning in high-need schools. The individual narratives and stories in this issue suggest reforms to encourage cohorts of students, both male and female, to pursue science, technology, engineering, and mathematics.

Vander Vliet, Jessee, and O'Brien describe a three-year research process at Lewis University aimed at transforming practice in middle school and college classrooms. Their project began with professional development and then moved to action research on the impacts of classroom transformation on students. Their professional development design includes theories and practices advanced by Michael Gurian, Sadker and Sadker, and Lise Eliot.

Kiihne and her colleagues at Illinois College ask, "Are there ways to reach middle school girls in the classroom without negatively affecting the learning of middle school boys?" Their study began with a survey of boys and girls in middle school classrooms and extended to an examination of learning preferences. The teachers wanted to see whether offering choices of activities changed student attitudes toward math or science and whether there were differences between boys' and girls' responses. Kiihne discusses how the question and survey data led the collaborators to examine girls' persistence in STEM through multiple lenses.

Dagenais presents the mission of the Illinois Science and Mathematics Academy (IMSA) to serve as a catalyst statewide for the advancement of teaching in science and math. He describes IMSA initiatives focused on middle schools, as the "appropriate level for acquiring... foundational learning outcomes" for specialized study in math and science. In particular, he explains the IMSA E2K+Program, a nationally recognized curriculum emphasizing inquiry and problem-solving -- designed to develop student interest in STEM subjects and prepare them to excel in science and math in high school and beyond.

Finally, **Pollock's** guest column moves the conversation about STEM from practice to policy. She discusses two major initiatives advanced by the Illinois Science Teachers Association (ISTA). The first initiative focuses on teachers as leaders in the sciences and delineates a career path for emerging leadership. The second initiative stresses collaboration across organizations to strengthen teacher preparation in the sciences. She is actively advancing this agenda as ISTA president.

Dawn Abt-Perkins' article introduces the Lake Forest College-Waukegan school district STEM partnership involving college professors and middle school teachers who are studying the influence of gender and classroom climate issues on student achievement and persistence in math and science in middle school through college. She describes a process of transformation that moved from teachers saying, "that's not our problem — girls do better than boys on everything from homework to test grades" to a shared recognition that gender differences do exist, ranging from learning styles to achievement patterns. Both teachers and faculty discovered that they have a lot in common in sharing ideas about building self-confidence, problem-solving skills, self-reliance, and persistence.

Waukegan middle school teachers **Atkinson, Selby, Campos, and Toledo** all write from the front lines. All of these authors have been engaged in action research that has transformed their math and science instruction. Atkinson writes about the impact of incorporating small group work and giving choices to improve engagement and positively affect girls' persistence in STEM classes.

Selby focuses on inquiry and learning style and the effect both have on "scientific stamina," i.e., student confidence, persistence, and resilience in solving problems in the science classroom. Building on this idea, Toledo assesses levels of confidence in both boys and girls and looks at factors that may increase confidence. Finally, Campos looks specifically at strategies that move girls in his classes from focusing on "good girl behaviors" to becoming more confident STEM students, using such strategies as "Think-Pair-Share" and group discussion.

Fischer and Schappe write from the perspective of college science professors. Fischer notes her own immersion in science and her growing realization that not all students come to the college science classroom with her level of confidence. She describes a reflective journey and the metamorphosis that occurred in her chemistry classroom when she began to analyze her student data in a manner sensitive to gender issues. She explains the changes she made in her classroom pedagogy and the resulting impact on her students. Like Fischer, Schappe explored the impact of gender in his science classroom. In a physics class designed for non-majors, he employed a survey questionnaire to examine learning preferences and then used video to examine his interactions with students. His article chronicles his quest to develop an interesting and relevant college course that is still "true" to the subject of physics.

Science, technology, engineering, and mathematics play a vital role in today's competitive world. To compete successfully, the United States must educate students, male and female, who are equipped to solve persistent problems such as global warming, create new cures for cancer, and develop sustainable energy sources. To produce such students, we must prepare great teachers, who are not only knowledgeable about STEM content, but who can facilitate STEM learning in such a way that increased numbers of students confidently return to their classrooms with an unquenchable thirst to learn more and more and more!

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Author Bio

Jan Fitzsimmons currently serves both as Director of ACI's *Center for Success in High-Need Schools* and as Instructor and Program Administrator for North Central College's Junior/Senior Scholars Program. She has developed an urban education internship at North Central College; served on a task force and co-chaired a symposium on P-16+ service learning; and is Curriculum Director and Campus Coordinator for ACI's *College Readiness Program*. Holding a Ph.D. in Curriculum and Instruction from the University of Chicago, Fitzsimmons leads program development for ACI's *Center for Success in High-Need Schools*, including curriculum design for ACI's *Teacher Induction Academy*, *Inner-City Practicum*, and *Diversity at the Blackboard* initiatives.

Lewis University ACI-SMLC: Addressing Gender Equity from the Elementary to University Classroom, *by Pamela Jessee, Suzanne O'brien, Valerie Vander Vliet*

Author Bios

Dr. Vander Vliet is a Professor/Chair in the Biology Department at Lewis University specializing in Microbiology and Immunology. She serves as the secondary education advisor and has taught the Special Methods: Secondary Science class. Dr. Vander Vliet is currently the co-director with Dr. Pam Jessee of the Lewis University ACI-SMLC team.

Dr. Pamela Jessee currently serves as the program director for the undergraduate special education program and is an assistant professor at Lewis University in Romeoville, Illinois. Dr. Jessee has more than 30 years in private and public education. She holds Illinois State Certification in the areas of Elementary Education, Learning Behavior Specialist I, School Psychologist, State Approved Director of Special Education, and General Administration including superintendent endorsement. She has served as a Special Education Coordinator, School Psychologist, and School Administrator in both general and special education.

Suzanne O'Brien, Ed.D. is an assistant professor of Special Education at Lewis University.

Abstract
In an effort to integrate gender specific content and pedagogy in the areas of math and science and provide professional development for both university and high needs school districts, Lewis University, in partnership with Union and Fairmont Schools in Joliet, Illinois, has been a member of the Associated Colleges of Illinois (ACI) Science and Math Learning Collaborative (SMLC) in a three-year grant funded project. Faculty from Union School in collaboration with the College of Education members of the Lewis ACI-SMLC developed and conducted four action research projects to investigate issues of gender differences specific to their experiences in the classroom with a focus on middle school females from low-income and minority populations. The studies included an exploration of gender-based visual and verbal differences, the use of geometric manipulatives to improve math abilities, improving math computation skills with self-monitoring and math computation practice and repetition, and finally an examination of female versus male performance in different aspects of science fair projects.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Introduction
According to the National Association of School Psychologists, "gender bias is alive and well and in some ways growing in the American classroom. School practices continue to send boys and girls down different paths too often treating them as different species." (Sadker, Sadker, & Zittleman, 2009). This bias may in large be the contributing factor to the underrepresentation of females in science, technology, engineering and mathematics (STEM) fields. According to the National Academy of Sciences (NAS), "it is not the lack of talent, but intentional biases and outmoded instructional structures that are hindering the access and the advancement of women. Neither our academic institutions nor our nation can afford such underuse of precious human capital in science and engineering. The time to take action is now." (NAS, 2007, p. 1).

The NAS notes that women are likely to face discrimination in every field of the sciences and engineering and they call for a close look at the research that refutes commonly held beliefs about women in these fields (NAS, 2007). Although increasing numbers of women are earning advanced and terminal degrees in STEM fields, they continue to earn less than their male counterparts and experience, perhaps unintentional, employment bias in both the ability to secure a position in their field and be advanced to leadership positions (www.nsf.gov/statistics/ seind08/c2/c2s4.htm). For minority women in higher education, the discrimination is two-fold as women of color are less likely than men either to be in tenure track positions or to hold positions of leadership. The research indicates that Illinois lags behind the nation in the percentage of women 18-24 years old who are earning degrees--13.3% in Illinois compared to 22.8% nationwide (Illinois Department of Employment Security, 2006).

These barriers constitute a substantial waste of human resources at a time when this country is desperate for innovation, creativity and a well-educated populace in order to solve energy, environmental and economic dilemmas. The problems do not begin at the university level; indeed a substantial amount of research indicates the presence of gender bias as early as the elementary and middle school years (www.edchange.org/multicultural/papers/genderbias.html). Illinois has a critical shortage for qualified STEM educators, more than half of middle school teachers lacking a certificate in the subjects they are teaching (www.keepingillinoiscompetitive.niu.edu/estem/pdfs/STEM_ed_align_7-1.pdf). In response the Associated Colleges of Illinois (ACI) created the Science and Math Learning Collaborative (SMLC). The SMLC is a statewide initiative intended to transform teacher education curricula, as well as offer professional development for inservice teachers in order to develop a teacher cadre capable of embedding gender-equitable pedagogy in middle grade mathematics and science curricula, targeted particularly for low-income and minority females.

As a partner in the ACI-SMLC, Lewis University (LU) affiliated initially with Union and then Fairmont schools in Joliet and Lockport, Illinois (respectively). Lewis University offers a value-centered curriculum rich in its mission values of knowledge, fidelity, wisdom, and justice and guided by the spirit of association, which fosters community in all teaching, learning, and service. Lewis is a dynamic, coeducational, comprehensive, Catholic university with a richly diverse student body, including traditional-aged student and adults of all ages. Union School District #81 serves the southeast section of Joliet in a rural single building housing a K-8 program, typically with 160-170 students, the majority being white (54%), 19.2% Black, an almost equal percentage of Hispanic students (19.9%) and the remaining students indicating Asian/Pacific Islander, Native American, and multi-racial. Fairmont School District # 89 is also a one-school district and the students include a mixture of African-American, Hispanic, and Caucasian students. Fairmont is located in an unincorporated section of Lockport, serving 324 pre-K-8 students. Arrangements for a third partner school, most likely in Chicago, are currently being negotiated.

Project Overview

The ACI-SMLC goals are three-fold: • Transform middle grade teacher education curricula through the integration of gender-specific content and pedagogy with the intent to change the math and science experiences for girls in grades 4-8. • Provide professional development for inservice teachers both in terms of gender equity awareness and content area expertise. • Increase the number of minority and low-income women persisting in the STEM pipeline.

The first year of our project focused on professional development at both Union and Lewis and measuring community awareness of the significance of STEM careers among Union's parents and stakeholders. Professional development included participation in Gurian Institute training, Fermilab workshops, and seminars associated with the LU May Faculty Institute. Institutional Review Board (IRB) training and action research proposals were completed and approved. The action research projects focused mainly on girls' mathematical abilities and the value of various practices such as spatial exercises, math minutes, and Rocket Math. One project, using rubrics, analyzed the performance of girls vs. boys in various aspects of science fair projects. A community survey based on one developed by Public Agenda was distributed to Union school parents with the intent of gauging the understanding of the significance of mathematics and science education, particularly for girls. Three of the four Fairmont teachers (grades 4-8) received Gurian and action research training and all four participated in an online-blended reading group headed by

Dr. Velda Wright of the Lewis College of Education (COE) on Boys and Girls Learn Differently (Gurian, et al). IRB training and action research proposals are in development.

At the LU May Faculty Institute, the ACI-SMLC team presented a workshop entitled “Responding to the STEM Crisis: Encouraging Women and Minorities in Science, Technology, Engineering, and Mathematics from Elementary to Graduate School” with Veronica Arreola, the director of Women in Science and Engineering (W.I.S.E.) at the University of Illinois at Chicago as a guest speaker. A reading group composed of LU faculty from math/computer science, sciences, and education focused on the NAS publication Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering and is sponsoring an Arts and Ideas presentation in Fall 2009 on the multiple factors that impact the integration and success of women in STEM careers. Panelists will describe their experiences as women who have pursued careers in these and related fields. An interdisciplinary workshop is being offered in Spring 2010 by a COE faculty member and the Lewis College of Arts and Sciences (CAS) Women's Studies director on gender equity awareness and its pedagogical implications, particularly in preservice math and science curricula both for elementary and middle school education majors and secondary education majors in math/computer science and the natural sciences.

Project Outcomes and Impact

Because of the ACI-SMLC grant COE and CAS faculty members have come to know and work with each other in ways that would not have occurred otherwise. COE faculty responsible for basic foundational courses and math/science methods courses and the CAS math/computer science and natural science faculty have become more aware of the pedagogical implications of gender associated inequities in learning experiences at all levels of education through seminars and workshops for LU students and faculty and teachers and students of our partner schools. As an example of the extent to which this grant has impacted LU faculty, biology and physics faculty members not members of the ACI-SMLC team developed online content specific mini-courses last summer for partner school teachers. Mini-courses in physiology, mechanics, electricity and astronomy were chosen as the result of surveying the teachers as to their specific needs. Online mini-courses in mathematics are currently being developed. All of these modules will become available to the newly recruited partner school in the last year of the grant. Faculty responsible for the pre-service education classes are evaluating syllabi and conducting surveys within classes to gauge the awareness and comprehension of gender-equity issues for revision and/or extension of syllabi in these areas.

The effect of participation in the LU SMLC project on our partner schools is most evident in the Union School District which has completed their action research projects and are in the process of closing the loops – acting on the insights gained as a result of their research. Working in conjunction with Dr. S. O'Brien a COE member of the Lewis ACI-SMLC, M. Grygiel, a grade 7 teacher, investigated the impact of Think and Draw Spatial Exercises with some results confirming research on male vs. female spatial abilities while others appear to be contradictory. Definitely concluded, as predicted in the literature, spatial skills improved with practice for both boys and girls. D. Caamano, grade 6 team member also working with Dr. O'Brien, studied the effect of the use of geometric manipulatives on the recognition of geometric forms and three-dimensional faces, edges, and vertices. The scores of the experimental group which used the manipulatives were definitely higher than the control group which only had access to diagrams. Unfortunately, differences between male and female students were not statistically significant because only 4 female students were enrolled in this class. Using Rocket Math, the grade 4 teacher C. DeCaprio, working with Dr. P. Jessee of the LU SMLC team and a COE faculty member, investigated whether these exercises' improved computational automaticity, as well as assessing the efficacy of self-monitoring of computational automaticity in girls vs. boys. One interesting finding from this study was the identification of a wide range of computational skills in fourth graders that warrants further investigation.

Dr. Jessee also worked with J. Michalak, the grade 5 team member, in a study of individual and overall ratings of female vs. male student science fair projects based on a rubric that scored not only the traditional components reflecting the application of the scientific method (hypothesis, procedure, materials, results and conclusions) but also criteria such as explanation of variables, knowledge of subject matter, student readiness, and the appearance of the display. The results of this study showed females scoring lower overall in the areas of conclusions and knowledge of subject matter while males scored lower on the appearance of the display boards. Recommendations for improving student performances in these areas include implementation of mini-projects with short oral explanations of the expectations of each criterion along with the incorporation of computer simulations for the production of the final display.

The analysis of these action research projects suggests that the professional development opportunities provided for the teachers prior to the implementation of the projects may have acted as a confounding variable that impacted the behaviors of their students. The teachers' heightened awareness of gender bias and differences could have influenced the performance of their students as the results of the study are contrary to what is known in the literature. In particular the work of Brownlow, McPheron and Acks (2003) who found that deficits in spatial abilities, particularly mental rotation (MR), may contribute to women's avoidance of areas of study that rely on MR, including chemistry. The females in this action research showed no difference in spatial abilities when compared to their male counter parts. In addition the SMLC team pondered the relationship between technology use and gender differences as they note the lack of research in this area. The team suggests further study in the following areas:

1. Survey students about their technology use and access.
2. Investigate possible differences in science fair judging between male and female judges.
3. Investigate curricular implications for gender disparity in computational automaticity.
4. Continue to investigate gender differences in visual/spatial orientation and verbal abilities.
5. Evaluate curricular content and assessment for verbal and visual skills in order to provide a gender balanced assessment system.

To sum up, the participants in these action research projects valued the experience and benefits received through professional development activities and intend to continue the implementation of what they have learned to insure more equitable pedagogy for the boys and girls in their classrooms. We also strongly recommend that professional development provided by the ACI-SMLC grant be expanded to include elementary level teachers, as some have suggested that subtle gender bias is present before the middle grades.

Future Plans

Our most immediate challenge is to complete the induction of the faculty in the third group of inservice teachers from our proposed third partner district. This will include Gurian training as well as professional development in action research, the organization of reading groups and access to the content area mini-courses. Action research projects are in the process of development at Fairmont while the Union ACI-SMLC team members are strategizing how to integrate and implement what they learned in their action research projects. As indicated earlier, professional development events will continue throughout the next year for both the inservice and university team members in the form of seminars, workshops, reading groups and the offering of a course for preservice teachers focusing completely on gender equity and its pedagogical implications. Coupled with the initiatives in the first two years, these efforts will allow the LU ACI-SMLC team to complete the first two goals of the SMLC: the transformation of teacher education curricula and the professional development of inservice teachers in gender equity and specific content areas.

One sector of the teaching and learning process that has yet to be addressed by the Lewis ACI-SMLC is the students themselves. Two science camps will be held this year at Lewis University at which female students will be able to participate in hands-on activities (molecular biology in the fall and computer programming in the spring), as well as attend a women's collegiate athletic event and meet with the women's team after the game. The intent is to acquaint middle grade female students with science experiences on a college campus while exposing them to multiple facets of collegiate life. Coupled with experiences provided through their school's SMLC team members, our aim is to spur more girls to enter and persist in STEM-oriented careers.

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Differentiated Instruction and Gender: Student Choices in Math and Science, *by Patricia Kiihne*

Author Bios
Patricia Kiihne teaches in the Mathematics Department at Illinois College and currently serves as department chair. She also serves on the Gender and Women's Studies Program Committee and was one of three coordinators for the 2008-2009 Gender and Science Reading Group at the college. She teaches a wide range of classes in mathematics and statistics. Her research interests include mathematics history, mathematics education, and women in math and science.

Abstract
Reversing the decline in the interest of middle school girls in math and science is a major goal of the Associated Colleges of Illinois' (ACI) Science and Math Collaborative (SMLC). If a girl's interest fades in middle school, she may fail to select the necessary coursework in high school to prepare for a future in math or science. She even may be steered away from appropriate mathematics and science courses by tracking (placing students into a set of courses based upon ability). This would leave her with a longer path to careers in areas such as medicine and engineering and may well discourage her from following these paths at all. Are there ways to reach middle school girls in the classroom, without negatively affecting the learning of middle school boys? Illinois College and our Jacksonville-area school partners undertook an action research project to answer this question. During the first year, we focused on the design of our project. Implementation of the project occurred during the second year.

Introduction
The variety of classroom situations represented on our team proved to be the major challenge we faced in designing our action research project. Of the six middle school teachers originally involved, three taught science; two taught mathematics; and one taught science and mathematics as part of the curriculum in her special education classroom. Finding a common curricular topic proved very difficult. Sager (1992) suggests that identifying a commonality can be looked at on a continuum, ranging from a shared process with different foci to investigating different aspects around a shared focus (p. 26). In one shared focus approach, teachers may pursue a common interest by looking at aspects of similar classes; in another, they may be focused on a single concept but with each teacher investigating a different aspect of that concept. A team working with a shared process and different foci may have a common overarching question, which each investigates in her or his individual classroom context.

The model with shared process and different foci gave us a way to accommodate both our differing curricula and our common goals of improving student performance – especially among girls -- in math and science. The broad question we chose was how differentiated instruction affects student learning; each middle school teacher then adapted this question to her classroom, i.e., a shared process of differentiated instruction with the focus depending on the individual classroom situation. We also considered whether gender made a difference in the effects of differentiated instruction on students. Individual teachers developed differentiated instruction units for use in the classroom during the 2008-2009 academic year.

We began by learning about the ways in which learning differs between girls and boys. This activity included two training sessions with the Gurian Institute, including research indicating that differences in learning styles of boys and girls are due to biology (Gurian, Stevens, & King, 2008) and strategies for better reaching boys and girls in the classroom. While there are several possible explanations for gender differences in learning, many gender scholars recognize the need to incorporate classroom activities that accommodate the different ways boys and girls learn. For example, Becker (1999) suggests "sharing problem-solving" as a way to involve more interpersonal connection among students in a mathematics classroom (p. 169). In shared problem-solving, students work in groups to solve multiple-step problems. Jacobs and Becker (1997) refer to building a community of learners as a way to meet the needs of female students (p. 111). This collaborative approach is consistent with activities mentioned at the Gurian training. Moreover, Gurian, Stevens, and King devote a chapter to the power of providing students with choices (pp. 69-86). Equipped with this information, the teachers in our group recognized the need to meet the students where they are and to acknowledge individual differences.As we further developed the study, we also examined the work of Sadker, Sadker, and Zitleman (2009), who note that “gender issues are dramatically impacted by race, ethnicity, and class” (p. 293); students are affected by all of these influences and should be treated as individuals.

Differentiated instruction allowed us to work with individual learning styles. According to Tomlinson (1999), teachers providing differentiated instruction offer “specific ways for each individual to learn as deeply as possible and as quickly as possible, without assuming one student’s road map for learning is identical to anyone else’s” (p. 2). Tomlinson indicates that teachers in differentiated classrooms “accept, embrace, and plan for the fact that learners bring many commonalities to school, but that learners also bring the essential differences that make them individuals” (p. 2). These aspects of differentiated instruction make it an ideal way to reach the different needs of boys and girls in middle school mathematics and science classrooms. A classroom may be differentiated in terms of content or activities. For our project, we chose to keep content consistent for all learners in a particular classroom, our shared focus being the differing ways students demonstrated that knowledge. Students also could choose among activities specifically designed for them to learn particular ideas. Tomlinson indicates that an activity is likely to work for students if it “has a clearly defined instructional purpose, focuses students squarely on one key understanding, causes students to use a key skill to work with key ideas, ensures that students will have to understand the idea, helps students relate new understandings and skills to previous ones, and matches the student’s level of readiness” (p. 43).Teachers on our team collaborated in developing such activities. Pre-service teachers contributed to the project by contributing materials on differentiated instruction in their student teaching classrooms that they were using in their pre-service education classes.

Methodology

Teachers administered a student attitudinal survey about mathematics or science and learning preferences before the initial differentiated instruction unit and then again towards the end of the academic year. We wanted to see whether offering choices of activities changed their attitudes toward math or science, and whether there were differences between boys’ and girls’ responses. Specifically, we made four comparisons: male scores at each school before and after the differentiated instruction unit; female scores at each school before and after each unit; male and female scores by school before the unit; and male and female scores at each school after the unit. In the aggregate, 203 students from the partner schools responded to the survey.

Interestingly, responses in the main did not support attitudinal and learning differences between boys and girls in statistically significant ways. Indeed, student responses were less favorable on a number of questions following the post-differentiated instruction than on the pre-differentiated instruction test. The notable exception, perhaps significantly, is that most of the female students reported that, as a result of differentiated instruction unit, they were working harder in their science and math classes on the post-test than their male counterparts. Also, girls at one school reported that science and math are more challenging to learn than boys had indicated; at another school, girls indicated on the post-test a higher regard for the usefulness of math and science than did their male counterparts. Additional research would be necessary to reach more refined conclusions regarding male and female differences. Although the survey had limited value in guiding the design of the project’s differentiated instruction units, the quantitative results suggest that the discovery of statistically significant attitudinal and learning differences between boys and girls is elusive.

The survey asked students to respond to these 15 questions on a scale of 1 (strongly agree) to 5 (strongly disagree): Learning mathematics/science is important to the world around me.

1. I look forward to learning mathematics/science.
2. I find mathematics/science challenging.
3. I am comfortable with mathematics/science.
4. It is useful for me to use inquiry to learn mathematics/science.
5. I like writing about mathematics/science.
6. I like to choose between learning activities.
7. I learn best by listening.
8. I learn best with hands-on activities.
9. I like to show my learning through artistic projects.
10. I like to work in groups.
11. Knowing mathematics/science will help me get a job.
12. I like to watch videos about mathematics/science.
13. When learning about a new idea in mathematics/science, I like to relate it to what I already know.
14. How much effort do you put into your science/mathematics work?

(Readers who would like to receive a complete tabulation and fuller analysis of survey results may email Patricia Kiihne at Illinois College, pkiihne@illinoiscollege.edu).

Differentiated Learning Units and Teacher Reflections
Each participating teacher developed one or two differentiated instruction units. (One teacher joined the project later and did only one unit.) Each teacher wrote reflections based on her units. The reflections may be more revealing than the survey of their students. The following is a summary of one unit from each teacher, along with her reflection. Melinda Baumann at North Greene Junior High developed a unit on resource management for grade 8 earth science. The unit objectives included a description of the following: how fast the human population is increasing; the reasons for the rapid increase in human population; the ways humans affect the environment; the steps individual students can take to protect the environment; the ways to conserve resources; the pros and cons of recycling; the types of water pollutants and their effects; the different sources of air pollution; how air pollutants affect people and the environment; and how air and water pollution can be reduced.

She gave students two choices for working with vocabulary: using all vocabulary words in a sentence or choosing 10 vocabulary words and demonstrating them in four ways (the book definition, a definition in their own words, using the definition in a sentence, and drawing a picture representing the vocabulary word). She also offered them a choice between several projects, including journaling about their consumption or their recycling, or researching pesticides used in agriculture or around the home. Students were invited to present their findings to the class.
In her reflection following the unit, Baumann noted:

Students were becoming more comfortable at the end of the year with picking activities and projects on their own. The quality of the work was also getting better, and there were fewer questions as the activities started. This being said, many students still complained they still did not like to pick their projects and activities and wished I would just give then exactly what I wanted from them, step by step. Students still preferred to have assignments given to them as they had been in the past. This coming year I will start this process with my 7th graders and work with them over a two-year period. I believe that learning greatly increased as they took on more responsibility in how they learned the material. Collecting and grading the individual projects was also getting easier as the teacher. Organizing how and when the materials are to be turned in will be something I will continue to work on this coming year.

Linda Brown of Virginia Junior High developed a unit on integers for a grade 6 mathematics class. Objectives for the unit included identifying and graphing integers; finding opposites and the absolute value of an integer; comparing and ordering integers; locating and graphing points on a coordinate plane; adding, subtracting, multiplying, and dividing integers; solving integer equations; and, as a more challenging objective for certain students, recognizing negative exponents by examining patterns. She differentiated by offering two types of assignments on each objective: a more basic one for 50 points or a more challenging one for 75 points. Students chose which assignment to complete and also had the opportunity as a class to learn about ordering by placing themselves at the appropriate spot on a number line for their integer. Addition and subtraction of integers was reinforced not only by using two-sided colored chips but also by using computer activities. Students also chose different graphing activities in which they plotted points to form pictures.

In her reflection following the unit (her second differentiated unit), Brown observed:

I found this unit easier to manage in the classroom [than my first one]. That was probably due to the fact that everyone, including me, had gone through a unit prior to this one. The test results were very good, considering the level that many of these students usually work. The behaviors during the whole class activities were much better this time. Management of time went more smoothly this time as well. Overall, I was very pleased with the unit. There will not be any changes made to this unit for future use.

Annette Jones of Turner Junior High in Jacksonville, IL developed a unit on light waves for her grade 8 science class. Objectives for her unit were to explain how electromagnetic waves are produced; describe the properties of electromagnetic waves; explain differences among kinds of electromagnetic waves; identify uses for different kinds of electromagnetic waves; describe the wave nature of light; explain how light interacts with materials; and determine why objects appear to have color. Jones indicated:

The learning objectives for this chapter were broken into four groups. Each group of objectives had three or four activities from which the students could choose. Choices included artistic, as well as written activities; thus, the differentiation was self-selected. However, the instructor maintained more control over what objectives the students were studying with their selections.

In her reflection following this unit, Jones explained:

Following the first unit of study, I experimented with different ways to incorporate differentiation into my curriculum. The process progressed from a list of activities based on point value to one based on objectives. In the first unit some students did several activities on one concept. In the last unit the students were forced, by design, to study all the concepts. The latter produced a more educationally sound unit.

Although my class has been using differentiation by means of self-selection for most of the year, the majority of the students still did not exhibit the change in frame of mind I would like to see regarding their learning. Grouping the activities according to objectives gave me more control over what concepts students were studying. However, students continued to choose assignments that were more traditional and appeared to be "easier." My goal is to get the students to the point in which they identify areas on which they need more review and choose assignments that will both interest them and help them review those areas.

Grouping the activities according to objectives was much less of a bookkeeping problem than the first unit. I had the students choose their activities at the beginning of the unit and only made copies for those that wanted them. This resulted in a great reduction in paper waste. I recorded grades according to concept rather than assignment so record keeping on the computer grading program was also simpler.

Getting students to correct their work for an improved grade continues to be a challenge. Changing students' attitudes about learning from "what does the teacher want me to do" to "what do I need to know to succeed" will help with completion of corrections.

In the future I plan to develop a quiz over each concept. Students will then choose activities to complete according to the quiz results. In this way I hope to help students focus on what is needed for success. In addition, I believe I need to focus more time on the purpose of learning and the power each student has over his/her education to foster a change of attitude. I continue to be convinced that differentiation is a method that helps students focus on their needs. Therefore, I feel that differentiation will result in increased learning on the part of the students. More power over what they are learning is also given to the students through differentiation. This empowerment should build confidence in their ability to learn science. Differentiation is a method that I will continue to experiment with and adapt to my curriculum.

Caroline Sturgeon of Meredosia Junior High developed her first unit on the nature of science for her grade 8 science class. Objectives for her unit included formulating hypotheses that can be tested by collecting data; conducting scientific experiments that control all but one variable; collecting and recording data accurately using consistent measuring and recording techniques and media; explaining the existence of unexpected results in a data set; interpreting and representing analytical results to produce findings; reporting and displaying the process and results of a scientific investigation; and identifying and reducing potential hazards in science activities. She provided an activity grid for students and had them choose activities in each column on the grid. She had students do one common lab activity; another activity, "You Choose your Path: Diet Coke and Mentos Lab," used differentiation in which each group chose what independent variables they would use.

Sturgeon noted in her reflection:

Next year I will not be using the grid. This grid was too much for the students to handle right at the beginning of the year. Instead, I will just tell the students different options available to them each day. I will still have my groups be 2-3 students of the same sex. By having students of the same gender, there were far fewer complications than with mixed gender groups. I will not give a grade on content during the differentiated instruction time. I will just let students work at their own pace correcting information as many times as it takes to get it correct. Knowledge is more important than a grade.

Sandra Sweatman of Turner Junior High in Jacksonville developed her unit on surface area and volume for her grade 8 mathematics class. Objectives for this unit included constructing nets for three dimensional figures, calculating surface area of three dimensional figures, and calculating volumes for three dimensional figures. She offered students different activities depending on ability: Weaker students worked with rectangular prisms, and stronger students worked with square pyramids and triangular prisms. She also gave students the opportunity to work in groups.
In her reflection, Sweatman reported:

I feel that this unit was fairly easy to differentiate. Also having had these kids for seventh grade as well as eighth grade gave me an advantage in that I had a really good idea of their learning levels. They responded to this unit being differentiated very well. I differentiated according to ability. I think that differentiating by interest or learning style would also be fairly easy in this unit and would probably be just as successful. I look forward to doing this unit again next year and maybe trying a different way to differentiate other units as well.

Many of the teachers reported that students initially were disconcerted by the differentiated instruction units. They wanted to be told exactly what assignment to do rather than to be given an option for different tasks. Much of the first unit administered in each class was spent helping students decide what they should do. Teachers also reported issues of procrastination for units in which a specific number of tasks were due at a set date. The second unit of differentiated instruction went better for the students because they were more accustomed to the idea of being able to choose learning tasks.

Pre-Test and Post-Test

In the second year of the grant, we increased our emphasis on student content learning. With this in mind, several of the teachers had students complete a content pre-test before the second differentiated instruction unit and a post-test afterwards. The average student scores for the pre-test and post-test at each partner school appear below:

Class	Pre-test Average	Post-test Average
Turner math	6.5%	76%
Virginia math	30%	74%
Meredosia science	28.4%	80.2%
North Greene science	42.0%	83.6%
Turner science	21.7%	63.4%

We see that in each case the students' knowledge increased significantly between the pre-test and the post-test. Unfortunately, although these learning outcomes are dramatic, without baseline pre-test and post-test data for the same objectives (that is, taught without the differentiated instruction), we cannot conclude with confidence that the learning increase was directly due to the use of differentiated instruction. Nor does the increase in content learning by itself provide insights regarding differences in learning of boys and girls. Nonetheless, the learning gains alone are impressive.

Conclusion

Our study had a number of limitations, including small class sizes in some instances and the limited number of differentiated instruction units included. We were not able to determine why students responded as they did to the survey. More specific questions could be used as a follow up, particularly for those questions in which there were differences in survey responses, either between the pre-unit survey and the post-unit survey or between male and female responses. A more longitudinal study would allow us to track student responses after the offering of more differentiated instruction units. Because many students were unsettled when they were given options, more units would allow them to adjust to the idea of choosing learning activities. Given that students were learning how to navigate the differentiation process while participating in the study and that the time for the number of units was limited, the results may be a reflection of student frustration with the new instructional method instead of a reflection of what was happening with their actual learning. Students also may have brought in preconceived notions about how they, either as individuals or as members of a particular gender, best learn and make their choices accordingly. Some of this might be avoided by providing more direction in offering particular choices. However, we need to be careful not to stereotype in our expectations. Sadker, Sadker, and Zittleman analyze the challenges involved in trying to provide a setting in which students make choices free of gender expectations (pp. 294-296).

We did not find significant differences either between the pre-unit survey and post-unit survey at each school or between gender responses at each school. Multiple differentiated instruction units and tracking over a period of years might help to identify such differences, as well as differential patterns. This particular study does not discredit the work of scholars such as Gurian or Sadker; however, a more longitudinal study might have results that support one or the other view. In our opinion, this study should be viewed as a pilot study aimed at identifying particular issues for further investigation utilizing a more refined research design. Hence, the results should be viewed as preliminary. Some questions that might be considered in a future study include: Why did individual students choose particular learning activities? How much impact did student resistance to the idea of choice have on their responses to the survey questions? Why did some students more strongly agree that they learned best by listening after they had been offered choices? What role did differentiation play in the learning gains of students? What impact did a student's choice of activity have on actual learning? Finally, what insights might the research reveal regarding the instructional preferences and learning styles and outcomes of boys and girls?

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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High Poverty Families + Low Performing Schools Add Up to Zero for Students, *by Raymond Dagenais*

Author Bio
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Abstract
The Illinois Mathematics and Science Academy (IMSA) serves as a catalyst to improve teaching and learning in mathematics and science. This article describes IMSA initiatives that have statewide impact, including the IMSA Excellence 2000+ (E2K+) Program, which is designed to enrich mathematics and science exploration among middle school students. E2K+ addresses Illinois State Board of Education (ISBE) learning standards and recommended National Science Foundation (NSF) Science, Technology, Engineering, and Mathematics (STEM) learning outcomes.

Introduction
The difficulties that the American educational system faces today were predicted in the 1980s. Analyses of the educational achievement levels of American students compared to those of their parents painted an alarming picture. The scope and importance of this finding is reflected in a declaration in A Nation at Risk (1983, p. 9): "Part of what is at risk is the promise first made on this continent: All, regardless of race or class or economic status, are entitled to a fair chance and to the tools for developing their individual powers of mind and spirit to the utmost."

In 1986, the state of Illinois established the Illinois Mathematics and Science Academy (IMSA) "to serve the people of Illinois as a preparatory institution and the school system of the State as a catalyst and laboratory for the advancement of teaching" (Illinois Senate Bill 730, The Comprehensive Illinois Educational Reform Package, Art. III, Sec.1). The responsibilities outlined in this bill were to offer a uniquely challenging education for talented mathematics and science students and stimulate further excellence for all Illinois schools in mathematics and science.

In the intervening years, various initiatives were advanced to stimulate excellence in all Illinois schools in mathematics and science. The best attributes of these initiatives have survived.

What Was Learned
The underlying purpose of these initiatives was to work with others to improve mathematics and science teaching and learning in Illinois schools so that Illinois students obtained the opportunities they needed to succeed. The question boiled down to: How might this objective best be accomplished? Some realities and practicalities helped shape the outcomes. Illinois has more than 850 school districts, many with multiple schools. The number of mathematics and science teachers in these schools was in the thousands. Tens of thousands of students would need to be served.

It became immediately apparent that IMSA did not have the capacity to work directly with all students in Illinois schools. The strategy of partnering with schools, especially high-need schools, to work with mathematics and science teachers emerged as a viable solution. This categorization is not limited to urban schools, because rural and even suburban schools also fall into it. Working with schools to effect changes in their mathematics and science curricula and teaching approaches for the purpose of helping students learn mathematics and science has proved daunting. Many schools had curricula that they felt served their students well. Experienced classroom teachers often were reluctant to consider modifying their established practices. The model that emerged was designed to address these challenges.

Program Rationale

To pare down the task to a manageable size, it was decided to target student population in middle school grades 6, 7, and 8, particularly in high-need schools. High-need schools can be characterized as schools serving students that do not have educational opportunities comparable to students at more affluent schools. This decision was made for several reasons. One reason was the mathematical and scientific content taught at this level. For example, The Atlas of Scientific Literacy (2001) identifies the following material as appropriate for grade levels 6-8, including the learning benchmark in the strand on the earth's gravity (found below the map on page 43): "Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass."

While this benchmark can be explored with a great deal of sophistication at higher grade levels, it is critical for students to gain understanding of basic concepts before using the technical vocabulary associated with these notions and the abstract mathematics that lend themselves so well to descriptions and predictions related to the earth's gravity. Middle school is the appropriate level for acquiring these foundational learning outcomes.

The key expectation here is to initiate and begin to deepen understanding, which leads to another reason for choosing the 6-8 grade levels. At the middle school level, students are being offered opportunities to experience many things unavailable to them at a younger age. Unfortunately, many of these activities often do not tap into the curiosity students at this age have regarding the world around them, as the following short version of extracurricular activities offered to students at Gregory Middle School in Aurora, IL, attests: Boys' Soccer; Volleyball; Cross Country; Girl Scouts; Student Council; Football; 8th Grade Magazine Fund Raiser; 7th Grade Magazine Fund Raiser; 6th Grade Magazine Fund Raiser; Orchestra Auditions; Band Auditions; 8th Grade Chorus; 7th Grade Chorus; and 6th Grade Chorus.

This listing does not include any family-initiated or church-affiliated activities in which students might choose to become involved. Drawing from observations of parents, young children appear curious about the world around them and desire to investigate the way things work. It can be argued that this curiosity and willingness to explore does not disappear as students grow older but may be set aside as a priority as students take advantage of many of the new opportunities presented to them. Peer pressure "to not look different" also can play a role in the seeming lack of interest of many students in mathematics and science during middle school. Students have so many things that take up their time at this age that spending time to explore mathematical and scientific ideas is not often on their radar screen.

A Nationally Recognized Program

For these reasons, IMSA created and developed the IMSA Excellence 2000+ (E2K+) Program, modeled after the highly successful Mitchell Excellence 2000 Program for junior high students in Israel. The IMSA E2K+ (6-8) Program is an after-school program for middle school students and their teachers. It is run by local school personnel at their respective school sites. In school year 2007-2008, IMSA's E2K+ Program was selected as one of the "Best Practice" Science, Technology, Engineering and Mathematics (STEM) Programs to be showcased at the STEM Education Diversity Forum hosted by Bayer Corporation in Washington, D.C. IMSA's E2K+ Program was cited for having "a proven track record of helping girls and underrepresented minorities to participate and achieve in STEM."

The primary goal of IMSA E2K+ is to maintain and increase students' interest in mathematics and science so that students will be inclined to study these subjects high school because of their previous success and enjoyment in learning these subjects. This goal was written to combat oft-heard comments like, "I hate science, and I'm not any good at math. All I want to do is take the minimum number of math and science courses I need to graduate." Since the beginning of IMSA E2K+, 142 students have been accepted into IMSA's highly selective regular school year program.

Using enrichment rather than an accelerated approach, IMSA E2K+ (6-8) strives to move students through increasingly more sophisticated levels of mathematics and science at earlier grades, providing students with multiple perspectives of mathematical and scientific concepts, principles, and habits of mind. This approach allows students, when confronting novel situations, to apply a variety of problem-solving techniques based on their prior exploration of these ideas.

The IMSA E2K+ enrichment approach is not intended to take the place of regular classroom instruction or replicate it for the purpose of added practice. Material learned in the regular classroom, coupled with the opportunity to engage in mathematical and scientific inquiry in the IMSA E2K+ Program, helps students learn to be sufficiently competent, confident, and comfortable in their mathematics and science abilities that they choose to continue their study of these subjects in high school. The goal is that "all students — not just those who intend to pursue a scientific career — should learn how scientific knowledge is constructed. Basic scientific literacy will be mandatory for anyone hoping to fully participate in our future society as a responsible adult" (McGinnis, Sept/Oct 2009). Unfortunately, it is the student in the high-need school who is frequently denied this opportunity.

Regular classroom instruction in mathematics and science operates within the constraints of standards, tests, and time. State standards identify the material to be covered, and state tests check the degree to which students can demonstrate what they have learned. Many classrooms lack the time to allow students to engage in the inquiry of the IMSA E2K+ Program.

The IMSA E2K+ initiative has been designed to carve out an after-school block of time each week where inquiry teaching and learning can flourish. As noted in Inquiry and the National Science Education Standards (2000), "students do not come to understand inquiry simply by learning words such as 'hypothesis' and 'inference' or by memorizing procedures such as 'the steps of the scientific method' "(National Research Council, 2000). IMSA E2K+ provides a low-risk environment for students and teachers. Students are given the freedom to follow through on their own questions, and teachers can explore a variety of teaching strategies that they may be reluctant to test in their classrooms. This type of dedicated time period frees students from the many activities that normally fill their day so they can indulge their curiosity about mathematics and science without feeling guilty about neglecting one of their other interests.

Program Logistics

Middle schools apply to be invited to partner in the IMSA E2K+ (6-8) Program. To be accepted as an IMSA E2K+ (6-8) partner, schools must prove they have enough students to be able to support the program across grades 6, 7, and 8. The program requires that a potential partner school enlist a four-person team consisting of a certified math teacher, a certified science teacher, an individual to serve as site coordinator, and the school principal.

The IMSA E2K+ (6-8) Program is held at the partner school with local teachers running the sessions for a select number of middle school students. Students who have high interest and potential in math and/or science are invited to apply to participate at their school. Each school decides the day and times to host the program, usually once or twice a week during the school year. IMSA staff provides specialized training in the program's content and methods to selected E2K+ teachers.

The Curriculum

By design, the IMSA E2K+ curriculum developed by IMSA professional development and curriculum specialists is competency-driven, inquiry-based, problem-centered, and integrative. The curriculum explores selected mathematics and science topics. IMSA E2K+ curricular units are made up of a series of lessons. Each lesson has one or more activities. Usually, the units are theme-based, meaning that the lessons in the unit address a general theme. For example, the unit entitled "Supersize or Miniaturize? Achieving More or Less" looks at a variety of scenarios that deal with optimization (maximization and minimization) problems. The lessons' activities are designed so students can determine a maximum or minimum value for a given situation without using the standard approaches of differential calculus. Students engaged in a problem-centered challenge will employ inquiry techniques in an integrated fashion to develop understanding of situations that can be optimized and strategies for accomplishing this task. As Willingham notes, "Working on problems that are at the right level of difficulty is rewarding, but working on problems that are too easy or too difficult is unpleasant" (Spring 2009). IMSA E2K+ activities are designed to present such challenges to students.

Prior to the inception of the IMSA E2K+ Program, IMSA invited a delegation of educators to visit the Academy to identify the critical aspects of the academic program. After visiting classrooms, talking with teachers and administrators, interviewing students, and reviewing the written products related to teaching and learning at IMSA, the delegation presented their findings in terms of IMSA's Core Competency: the ability to conceive, design, develop, and demonstrate exemplary, competency-driven teaching and learning experiences and materials in mathematics and science that are inquiry-based, problem-centered, and integrative. The attributes of IMSA's Core Competency work together to inform design principles for STEM literacy.

IMSA Core Competency Attributes

Competency-driven learning experiences are those that enable students 1) to acquire strong bases of disciplinary content knowledge and skills, key ideas of the disciplines, and connections among these ideas; 2) to use the ideas, processes, and tools of the disciplines for acquisition and generation of new knowledge; and 3) to apply knowledge when addressing issues and solving real world problems.

Inquiry-based learning experiences are those that promote analytic thinking, knowledge generation and application, and meaning construction through mindful investigation driven by compelling questions that have engaged or have the potential for engaging the learner's curiosity.

Problem-centered learning experiences are those in which learners grapple with complex, meaningful and open-ended problems, and work toward their resolution.

Integrative learning experiences are those that forge meaningful connections of concepts, constructs, and principles within and across academic subjects and real-world situations.

In addition to designing and delivering teaching materials and approaches based on IMSA's Core Competency attributes, the IMSA E2K+ Program also considers the Illinois Learning Standards Applications of Learning (Illinois Learning Standards, ISBE, 1999) to be fundamentally important elements of the program. These applications of learning are stated as being able to:

The Nation at Risk report recognizes these abilities: "In our view, formal schooling in youth is the essential foundation for learning throughout one's life. But without lifelong learning, one's skills will become rapidly dated" (p 14). While the Illinois Learning Standards Applications of Learning are embedded in each unit's lessons, the lessons differ in the degree of emphasis they place on each Application of Learning. Some lessons emphasize working on teams and making connections to a greater degree than using technology and communication. Overall, E2K+ students are presented with ample opportunity to gain experience in practicing these valuable lifelong learning skills and behaviors.

Final Comments

The IMSA Excellence 2000+ experience offers students the opportunity to establish and deepen their understanding of selected mathematical and scientific concepts, principles, and habits of mind. The program has been designed to provide teachers with the curricular materials and teaching approaches that will support their efforts to grow professionally and assist willing middle school students to continue their explorations in mathematics and science. Not to be lost in the academics is the promise of learning how to learn so that students can become self-sufficient learners outside of school.

As the program has taken root, the initiative has expanded. Appropriate curricular materials and teaching approaches also have been created to include grade levels 4 and 5. This late elementary transition period lays a learning foundation for the inquiry that is promoted in the middle school program. The low-risk environment that characterizes both the late elementary and middle school programs allows teachers to try some teaching approaches that they may be reluctant to attempt in their regular classes because of curricular coverage requirements and time constraints. For students, the chance to explore their own questions in a guided fashion opens doors of possibility into their futures.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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Dreams from the Illinois Science Teachers Association, *by Gwen Pollock*

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Body
Recent conversations with leaders of Associated Colleges of Illinois (ACI) have brought about a most welcome opportunity to share the directions found in the 2009-2011 strategic plan of the Illinois Science Teachers Association (ISTA) (http://www.ista-il.org/strategic-plan-2009.htm). As President of ISTA, I feel the plan derives from the belief that the best science teacher-leaders can be empowered to increase excellence in teaching and learning science in Illinois.

There are two major venues for accomplishing the ISTA strategic plan. One venue focuses on the professional circles and networks of teacher-leaders; the other on the policy foundations that need to be broadened to meet the needs of our 21st century science teachers and their students.

The most visible ISTA initiative is our focus on teachers as science leaders able to address an ever-broadening circle of needs through special learning communities that support genuine conversations, spirited discussions, and networking opportunities. The following ideas are starting points for realizing the potential impact of science teachers throughout their careers:

We are thinking of the teachers who are within their first four years of teaching, possibly barely progressing alone from day-to-day with their content foundations, classroom responsibilities, and daily challenges. They need easily accessible, contextualized, and emotional support and options for action.

AND the teacher-educators in the post-secondary settings throughout Illinois' public and private institutions for the collective benefit of this broader learning community to develop like-minded dedication and research-based understandings in responding to both similar and unique challenges and their resolution.

AND the master teachers in K-12 settings who share a special kinship with teachers-to-be in their classrooms, again hoping for a collective benefit from a learning community that reaches beyond institutional frameworks and requirements to address their common and uncommon circumstances, challenges and their resolution.

AND retired teachers who have special insights and connections that can be shared with teachers-to-be still in undergraduate or first classroom settings — responsive to the multiplicity of rural/urban, north/south/east/west, elementary-to-secondary, poverty/wealth, content specific/generic questions and challenges teachers face — with the resources of a newly emerging non-formal expertise in Illinois.

AND the teachers who are mastering their responsibilities effectively and want to do more and better who are emerging with goals of leadership for their classrooms individually and collectively, through higher quality professional development opportunities, support and trust.

Simultaneously, ISTA will be pursuing strong partnerships with other professional organizations and leadership institutions to propose new or refined policy considerations that will push Illinois forward to venues that our collective expertise and energies can address effectively.

First, ISTA leaders are interested in the creation of an elementary mathematics and science specialist endorsement. We have realized that a new endorsement will require substantiation. It must include the latest research about how children learn mathematics and science. This research already shows how more effective guidance about teaching strategies, curricular processes, and assessment structures can enable teachers to help students learn better. The proposal must be modeled after the well-established Illinois reading specialist endorsement and should reference pertinent state and local policies that have emerged. The present culture of accountability requiring data analysis, interpretation, and action must be acknowledged and demonstrate how such expertise will help children learn and achieve more effectively. We also must acknowledge that the economic prospects (at local, state, and national levels) are improved through emphases on high-quality elementary mathematics and sciences. Finally, we should propose that Illinois' leadership responsibilities to guide local implementation of best practices at the elementary level can be expanded through this endorsement focus. We will offer a draft of teaching standards for the endorsement and gain support from a broad base of teacher-producing institutions.

Second, ISTA leaders, along with our colleagues from the Technology Educators Association of Illinois (TEAI), have offered their expertise and interests for the integration of engineering concepts and processes into K-12 teaching and learning. We already have submitted a sampler of refinements to the Illinois Learning Standards in Science so that the technological design concepts, principles, and processes specifically described in Standard 11B can be more effectively considered for curricular and assessment decisions throughout ILS Science goals 12 and 13. We are reviewing the Illinois Race-to-the-Top proposal, which has a significant focus on engineering and feel that our offer may have been made at a most serendipitous time. We do anticipate that if standards for students more strongly emphasize engineering, then complementary refinements for the Content Area Standards for Science and Technology Education, affecting the traditionally named Industrial Technology teachers, must be addressed as well. We have stressed the necessity to understand the role, nature, and impact of engineering in today's global society, more specifically in Illinois' economic future, building on the work of the National Academy of Engineering, the National Research Council, the International Technology Education Association, and multiple national research reports, describing the necessity of technological literacy for our citizenry and current/future workforce. We propose the necessity and framework of high quality professional development for K-12 teachers, whose curricular connections are vital to our technological literacy.

In closing, these dreams require a special collaboration of organizations and institutions with a collective fervor and supporting framework to achieve these empowering ideas. We need to encourage personal networks within and between professional organizations and institutions; they have been underappreciated and underutilized in recent years. The basic assumptions and traditions of these networks and organizations will need to be refined and redefined to meet the current and projected needs of our teaching members and the emerging teaching and learning cultures. The ensuing collaborations require careful attention; they cannot be personality dependent; they cannot be quick and careless. They must be well-grounded and strategic, optimistic and pragmatic, and encompass the influential decision-makers and dedicated worker bees with a common insight and passion for achievement.

As president of ISTA, I sincerely invite ACI colleagues to participate in this conversation, deliberation and action. Our collaboration will be empowering and invigorating.

Making the Invisible Visible: Professors and Middle School Teachers Study Classroom Climate Issues to Address the Persistence of Girls in Math and Science Fields of Study, *by Dawn Abt-Perkins*

Author Bio
Dawn Abt-Perkins is Associate Professor and Chair of Education at Lake Forest College. She is the co-editor, along with Stuart Greene of Notre Dame University, of *Making Race Visible: Literacy Research for Cultural Understanding* (2002).

Abstract
Abt-Perkins describes the Lake Forest College-Waukegan middle schools Science and Math Learning Community (SMLC) and introduces a series of action research projects by college professors and middle school teachers: Professors and teachers studied gender differences in their math and science classes, both in learning styles and achievement, and introduced new pedagogies to enhance learning and interest more girls in STEM careers.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Body
When I first started to work with middle school math and science teachers on the shortage of women in math- and science-oriented careers, the middle school teachers said: "That's not our problem. Girls do better than boys in our classes on everything from homework to quiz and test grades. They aim to please. If girls are choosing not to pursue careers in math and science fields, that is a matter of choice, not a matter for instructional reform."

On the other hand, the college professors with whom I worked were concerned. They saw the young women in their classes dropping their courses at the first unexpectedly low grade, not coming to office hours or tutorial sessions, and, in general, not persisting in major fields of study leading to engineering or math careers. These professors — a majority of whom are female — were perplexed by this phenomenon. Obviously, the role of the professor as female role model was not enough to encourage women to persist in these disciplines. Clearly, between middle school and college, something disturbing was happening that needed to be better understood to support girls in math and science. And, just as clearly, we were not sure what could be done about this problem by initiating instructional change. What, if anything, was happening in middle school and college classrooms that was working against girls moving ahead to math and science careers?

As a professor of education interested in equity issues on the classroom level, I developed a research project in which I formed three action research/study groups: one for middle school science teachers, one for middle school math teachers, and one for professors of undergraduate science and math courses. We met collectively for professional development lectures and follow-up discussions on gender issues in education. We also met separately in study groups and developed individual pedagogical change projects. We shared the results of our projects symposium-style before presenting them in mixed thematic groups of professors and middle school teachers at the ACI Arts and Science Colloquium.

The teachers and professors joined the project more because they were hungry for any kind of professional development that would address math and science instruction than because they believed in or wanted to pursue the problem of lack of gender equity in math and science fields. We began by studying the problem itself to begin to own the problem as something we could address through instructional reform. At first, it seemed as if the problem was not related to our instruction but was a cultural or social problem of expectations of women or a matter of personal taste:

It is not a teacher's fault that girls and women do not find science and technology careers interesting and relevant. How could teachers have any real influence on these social perceptions and stereotypes? How is this a teacher or pedagogical problem?

We began our action research project and study groups, then, by trying to better understand the influence of the teacher's role and instruction on the outcome of fewer women choosing math and science careers. An investigation of the research led us to the conclusion that girls and women lack sufficient self-confidence about their math and science abilities, and they perceive math and science as competitive, anti-social courses of study and career fields. These seemed to be the main reasons for the lack of gender equity in math and technology fields. Girls do get better grades in math and science classes through middle school, perform just as well as boys on standardized tests in these fields, and take as many advanced high school math courses as boys (Hyde et al., 2008). Clearly, girls are as capable and can perform as well as boys in these fields. However, girls are more susceptible to the cultural perceptions and stereotypes that girls are not good at math and science and tend to underestimate their abilities and attribute their success to external factors rather than individual talent or skill (Fouad, 2008; Kenney-Benson et al., 2006). In fact, a study of undergraduate women showed that those who see themselves as "strongly identified with being female" are more vulnerable to leaving math and science fields, regardless of their skill and performances in math study (Keifer and Sekaquaptewa, 2007).

Studies also show that girls care more about the social climate of their math and science classrooms than do boys. In fact, in high school, girls are more readily influenced by their peers' choices of math and science courses than are boys (Crosnoe et al., 2008). In other words, girls have a greater need than do boys to have their friends in their math and science classes in order to feel comfortable taking these courses. Girls also care more about classroom climate features such as competitive vs. cooperative constructs and explicit learning strategy instruction and less disruptive classroom behavior in math classrooms as compared to boys (Kenny-Benson et. al., 2006). Girls seem to gain confidence from math and science classroom structures that are collaborative and focused on explicit learning processes as they outperform boys in these classes. Yet, girls perform only equally well compared to boys on standardized tests; researchers attribute this difference in performance to lack of self-confidence in non-collaborative, competitive test-taking contexts (Kenny Benson et. al, 2006). Clearly, certain classroom climates feed girls' self-confidence in math. Equally clear is that girls' confidence in their own math and science abilities is fragile and in need of explicit support.

The next step in our study groups was to look more closely at how our classroom climates, structures, activities, and assessment systems build confidence and solidify student self-understanding and reflection about the study of science. I began our work in study groups with a series of reflection and observation exercises asking participants to reflect carefully about their own bias and perspectives on the gender effects in instruction, in general, and in math and science classrooms, specifically. I also had the teacher observe males and females in their classes in terms of participation structure. Some faculty surveyed students about their attitudes and learning dispositions and then analyzed the results according to gender. We needed to "see" the gender equity problem before we could begin to invent instructional approaches to address it.

Once we knew where to look, we found the problem in all kinds of unexpected places. Despite performing well, girls' persistence in studying math and science wore thin quickly. In college, this manifested itself in girls dropping courses at the first challenge—the first quiz grade that didn't meet their expectations, etc. In middle school, it showed up in teacher-dependency behaviors: needing to check all steps for "correctness" with the teacher before moving on to the next step; a lack of willingness to do extension or challenge activities; needing explicit instruction before approaching new problem sets or inquiry projects. In general, in middle school, girls need too much teacher support because they lack true confidence in their own abilities. This stops them from challenging themselves and pursuing the types of problems and experiences that would best prepare them for higher order math and science courses later on.

In our study groups, we shifted our focus to understanding and building a solid sense of self-understanding and confidence in all of our students, especially our girls and young women undergraduates. In our discussions across study groups, middle school and college teachers started to see a relationship between their instructional climates and instructional challenges. As college teachers shared their concerns about undergraduate women pursuing unstructured, open-ended problems, taking leadership in the laboratory, using creative/critical thinking and problem-solving skills to succeed in math and science classrooms, middle school teachers reflected about what they were teaching and rewarding as achievement in their classrooms. Reflecting on the outcomes, skills, and habits of mind embedded in their evaluation systems, middle school teachers found that they were rewarding "good girl" behaviors and were reinforcing teacher dependency in their assignment design. Indeed, students were getting more "points" and better grades for neatness, organization, completeness, and following directions and general teacher obedience than they were for creativity, leadership, initiative, problem-solving, the ability to take informed risks and learn from error, and scientific or mathematical independent thinking -- the very skills that the college professors identified as necessary for young women to succeed and persist in college-level study of math and science. The middle school teachers realized they weren't doing what they could to build self-confidence, and, consequently, to foster the ability to persist in the study of math and science.

In these same discussions, as the college professors listened to middle school teachers talk about collaboration, scaffolding of student skills, discussion and project-based learning, and how much these teachers knew about their students as learners as a result of this type of approach to teaching and learning, the college professors reflected about their own fast-paced, content-packed, lecture-based, and professor demonstration-based practices and found them to be lacking. Indeed, if they wanted to build student confidence, they would have to provide different opportunities for their undergraduate students to collaborate with them and their peers through discussion, use of multiple resources for their learning, and reflective assignments assessing and expressing their own sense of confidence and understanding in the material to guide their learning in productive ways. They needed to provide more and different opportunities for the young women in their classes to express their confusion, their concerns, and their misconceptions, so that the professors could do more formative assessment, know their students better as learners, and build a more supportive classroom climate for learning in which they could meet their students at their points of need.

Both middle school teachers and college professors planned instructional change projects to build self-confidence, problem-solving skills, and self-reliance or persistence. The middle school teachers decided to work from the desire of girls to please others, their social intelligence, by looking closely at how they designed collaboration in their courses and how they rewarded problem-solving skills—not just "getting along" or people skills—in collaborative work. They discovered that girls are more likely to take risks, learn from mistakes, and delve into unstructured problems when they are part of a group or a team.

The teachers also looked more closely at how girls participated in their classrooms. Getting the right answers, work completion, correct performances accomplished by following directions explicitly were all far too important to the girls. The teachers realized that they unconsciously supported these values and attitudes through their assignment design, evaluation rubrics, and feedback during class. The middle school teachers found new ways to listen to and guide girls in the skills and dispositions they need to be successful studying science and math at all levels. Teachers worked to redesign assignments, reconstruct how they handled class discussion, and focused their feedback on supporting initiative, creativity, and risk-taking. Teachers made more time for reciprocal teaching and other methods that focused on explanation of processes rather than simply rewarding following directions or step-by-step learning and correct answers. Teachers did more modeling of processes, demonstrating how to learn from mistakes and how to find support when one is confused. They encouraged students to do the same for each other. Teachers found new ways to support and assess the girl's growth as math and science students.

The college professors found time for demonstrations that required students to be active participants. They also used online technology tools, such as videos of their classroom demonstrations, to give students more opportunities to revisit material again and as needed. They embedded confidence measures into their assessment systems and allowed students opportunities to explain their misconceptions and confusions to one another in post-assessment, follow-up presentations and discussions. They developed different tools, such as journals and reflective questions on quizzes and exams, for helping students express confusion. Collaboration was no longer limited to the laboratory, but rather became part of the culture of discussion in these college classrooms. Students were asked to present both what they knew and what they were not sure about as part of the assessment of their learning. Professors searched for a multitude of formats and structures for course support material, including video and articles from popular science, academic journals, and textbooks.

Both professors and middle school teachers of science and math came to the same conclusions in their studies. Girls need to know themselves as math and science students, which means that their teachers need to be explicit about the true skills, dispositions, and learning processes necessary for long-term success in math and science classes. Girls need to be equipped not only with the content knowledge, but with the habits of mind necessary to continue to grow as students in these fields. Their self-confidence needs to be solidly based in detailed knowledge of how to study math and science. Teachers have a crucial role to play in supporting girls so that they have a real opportunity to work in science, math, and technology fields, so that the choice is truly theirs to make. In the papers on action research that follow, you will hear from the teachers who looked closely at this question of why girls did not persist in math and science and what they could do about it. They found they had plenty of work to do, after all.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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Gender Differences in Middle School Math, *by Angela Atkinson*

Author Bios
Angela Atkinson is a sixth grade math instructor at Robert Abbott Middle School in Waukegan, IL.

Abstract
Middle school teacher Atkinson describes how the use of small group work and providing students with choices can lead to increased learning engagement and greater persistence, especially among girls studying STEM.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Body
As a middle school math teacher, I have noticed many gender differences during my seven years of teaching. I recorded my impressions in a journal when I began this project: The girls in my classes excel and get the best grades overall. They seem to take school more seriously, complete their homework more often, and do better on tests than boys. Girls come better prepared for class, bring the necessary supplies and materials, and often begin working without further prompting from their teacher. Most girls are respectful and do a better job than boys of paying attention in class.

Boys do not complete their homework and do not seem to take school seriously. They have more trouble staying focused in class, are easily distracted by other students, and often play with items such as pencils, erasers, key chains, and anything else they can get their hands on. Boys are more often disciplinary problems. They seem to get easily bored in class or try to be the class clown to entertain their peers. I have had some male students who are very smart but have a hard time completing assignments because of boredom or laziness.

At the beginning of each school year, I let the students choose their seats for the first couple of weeks to see how they interact with each other. My students are seated at tables in groups of five. Usually, girls choose to sit with girls, and boys choose boys. Girls like to help each other and work well in groups; however, if one girl is a stranger to the others at the table, she tends to be left out of the discussions. The boys' tables seem to be more competitive than the girls' tables. The boys take note of who completes the assignment first and who did not do their homework, and they are very proud to beat one another at math games.

As I read Michael Gurian's Strategies for Teaching Boys and Girls (2008, Jossey-Bass), I learned about brain and chemical differences between boys and girls that provide physiological reasons for why they act as they do. All students come to school to socialize learn as well as to learn, whether we teachers like it or not. Consequently, my practice has evolved to include a lot of partner and group work. This allows the students to talk and learn as long as they are staying on task. I also noted that students, especially boys, need to move around and actually learn better when physical activity is incorporated into classroom exercises. Gurian contends that giving students choices about what and how they are learning keeps them engaged and benefits their developing brains through making new connections. The changes I made in my class reflect this principle.

Because projects and student collaboration are a large part of my classroom activity, I decided to study how each gender views each activity, the activity's benefits, and how I might use activity more effectively. This builds on the work I have done for the past three years using collaborative groups more effectively in math class. I have changed the way I set up my groups by mixing students of differing academic levels in each group. I would like to experiment with single gender groupings to see how they work and then observe which gender benefits more from it.

I also have developed job sheets so each member of the group has a specific job for which he or she is accountable. These jobs include: group leader, materials manager, data collector, time keeper and reporter(s). I rotate jobs so that students experience different group roles. I have dramatically changed my method of assessing students' group performance. I now use a group grading sheet in which all members of the group are individually graded, according to what they contribute to the group. I am studying the effects of these grade sheets on each gender. So far I have noticed that the girls are doing really well because they generally are the more responsible gender. This new grading system also seems to be helping some of the boys because it is forcing them to do the work instead of being a spectator.

I also have changed the way I assign and allow students to do projects. Instead of assigning a project to all students, I now allow students to choose their project. Students can also choose to work in groups or individually. Before they start, they must plan their projects, including listing the materials they will need. If they are working in a group, they are required to write down what each member is expected to do. Before students turn in their projects, I have them fill out a grade sheet listing the specific tasks that each student completed for the group project. Then I assess the projects by what each student did and the quality of their work. The group is given a total overall grade, and then I determine the individual grade for each student. So far, girls have had a much easier time coming up with project ideas than the boys. Some of the boys even asked me to give them a project idea. The girls enjoyed being very creative with their projects and adding many details.

I also administered a survey on how the students feel about doing projects and working with others. After my students designed and completed a summative project for the geometry unit, I surveyed 35 females and 28 males. I analyzed the responses for each gender to see how boys and girls felt about completing their geometry projects. Almost 70% of both boys and girls felt that the projects helped them to better understand the material. I was surprised to find out that more of the boys (82%) than the girls (77%) enjoyed completing the projects. A total of 83% of the girls (71% boys) liked working with other students. Fewer girls (43%) than boys (50%) said that all the members in their group worked on the project. More girls (69%) than boys (57%) said they would like to complete another project. Slightly more girls (66%) than boys (61%) feel they were given a fair grade on their project.

I also analyzed the grades that 41 girls and 33 boys received on their projects. I found that the girls' average grade for their projects was approximately eight points higher (89.5%) than the boys (81.2%) in each of my three math classes. I concluded that girls earn higher grades than boys on projects. Then, I calculated the test grades for that same geometry unit. The average test grade for the boys was 84.7%, compared to the girls' average test grade of 76.3%. Interestingly, the boys' test grades were the same eight points higher than the girls' project grades. Does this mean that the average final grade for that quarter should be about even for boys and girls? The girls' average final grade was 76.8%, and the boys' average final grade was 76.3%. The girls edge out the boys by .5%! Perhaps, this means that their scores are equal as long as you give them a chance to shine at whatever they do best.

In light of these outcomes, I'm considering several next steps, such as allowing boys to take a test to show their knowledge and allowing girls to complete a project to demonstrate theirs. This would give boys and girls the chance to be assessed according to how their gender performs best. On the other hand, assessing their performance on both tests and projects enables them to demonstrate their knowledge in more than one way and provides them some options. As both genders really enjoyed completing the projects, and the projects allow them to be creative, I will definitely keep using them.

My next challenge is likely to be improving girls' performance on tests and boys' performance on projects. When surveyed on their attitudes toward math and how they learn best, more boys (79%) than girls (60%) said they were learning a lot in math this year. More boys (68%) than (girls 57%) said that the teacher makes math easy to understand. I know I have a tendency to move through the material quickly when I teach. I think the boys might appreciate this speediness so they do not get bored, but I know some of the girls need me to slow down. More girls (74%) than boys (57%) felt they were doing their best work most days. The girls (69%) are more comfortable than the boys (57%) in asking me questions. The girls (71%) also felt more confident than the boys (64%) of the work they do in math.

It seems that the boys are learning a lot, and that math is easy for most of them to understand. The girls are doing their best work and are comfortable asking me questions. In class, the girls seem to be trying very hard and usually ask more questions than the boys. The surprising finding is that the girls feel more confident of their work than the boys. The reason may be that they ask more questions and take more time to complete their work.

A few other questions were asked to determine how the students work and learn best. Both boys and girls said they do their best work on their own, but working "with a partner" was a close second. Although at the beginning of class, girls and boys almost exclusively chose to join a group of their own gender, only 23% of the girls and 4% of the boys preferred same gender grouping. I am wondering if boys like to have girls in their groups because the girls do more of the work. Both boys and girls (50%) indicated that they like mixed gender groups the best.

A total of 54% of the girls said they learn best when I am teaching as opposed to only 31% of the boys. A close second for the boys was both working with a partner and doing a project (28%). This makes sense because boys are more impatient with listening to me. They just want to get into the problem and figure it out!

After compiling and examining all of this information, I have concluded that the girls need me to spend more time with them, and boys prefer to work things out on their own or with a partner. Consequently, I am thinking of having some type of small group work follow each lesson. Those who understand can get to work, and those who do not can come to me or another student for tutoring or review. Some of the students who understand and finish quickly could be in charge of one of the "re-teaching" groups.

I will continue to experiment with single gender and mixed gender groups. I am curious whether students will do better when they are not distracted by the opposite gender. I can also try these groupings on the days when we are reviewing for tests in an effort to improve girls' test scores. I could even do something similar with the boys by giving them a little more of my time and instruction on how to design and execute a great project.

Next year, I would like to survey all of my students after the first month of school. This will allow time for my students to experience my teaching style and for me to get to know my students. I will use these survey results to adapt my teaching methods to my students' needs and preferences. I would also like to experiment with the mixed and single gender groups early in the school year. I need to find a way to keep the boys engaged while I am slowing down my teaching to meet the learning needs of the girls.

Each year I seem to discover a new method or a better way of doing things. A major goal of mine is to have all of my students become self-directed learners, no matter what gender they are. If I can help to instill a love of learning in them, they will likely succeed no matter what they do.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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Building "Scientific Stamina" Through Inquiry, *by Karen Selby*

Author Bio
Karen S. Selby is an eighth grade science teacher at Jack Benny Middle School in Waukegan, IL.

Abstract
Middle school teacher Selby describes her efforts to develop "scientific stamina" in her students. Scientific stamina is a measure of the impact of methods of inquiry and learning styles in contributing to self-confidence, persistence, and resilience in solving problems in the science classroom.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Body
I was eager to be involved in this project, which examines gender differences in the fields of math and science. I previously researched gender differences in learning styles before writing my master's thesis, which was on the need for single-gender education. As in my master's thesis, I wanted to see if the gender stereotypes about learning styles were really true and why some children in math and science classes depart from those stereotypes.

Most educators view boys as hands-on learners and believe girls prefer discussion and interaction with teachers. My thesis research showed that I and my fellow eighth grade teachers subscribed to this philosophy as well. We believed that male students thrived in competitive environments and needed to be kept active and motivated, while female students needed to work in small groups that were conducive to discussion. As educators, we knew that if we provided instruction keyed to our students' learning styles, they would be more likely to succeed as learners.
One concern I had going into this study was finding a balance between up-front teaching and student-centered teaching. Even though I am something of a control freak, I knew my instructional practices had to change to better serve my students' needs and learning styles. As I went along, I learned that a mix of both teaching methods was desirable.

In the past, I observed that male students often were more involved in experiments but less likely to complete a lab write-up, while female students preferred to take notes and complete writing exercises. I knew my students needed more inquiry experiences, but I was at a loss as how to incorporate these experiences into my instruction.

In August 2009, I attended a study session at Fermi National Accelerator Laboratory, which helped me prepare for inquiry-based science instruction and made me less anxious about stepping outside of my comfort zone. I was given criteria to determine whether an activity was inquiry-based and was able to experience these types of activities and lessons from the contrasting perspectives of student and instructor. I also received support from the other science teachers, who provided guidance and a sounding board for my ideas.

As the school year progressed, I gained confidence in my ability to provide inquiry-based instruction. In our group meetings, the science teachers discussed the idea of "scientific stamina." We wanted to look at how students develop confidence, persistence, and resilience (the ability to develop problem-solving skills) in the science classroom. We were particularly interested in assessing and measuring stamina in our students and achieving gender equity in our classrooms. Throughout this process, I examined my own teaching practices and revisited my thoughts on why gender inequity exists in the fields of math and science.

Round One: Starting the Inquiry Process
I decided that I would incorporate some inquiry activities into the chemistry unit I teach every year. I wanted to try to move towards a more student-centered classroom and see what my students could do on their own. It was hard to "keep my hands in my pockets," as we science teachers like to say. I quickly found out that just giving my students a few directions would not suffice. My students had done experiments and observed demonstrations before, but most found it hard to make that leap to thinking through an inquiry process by themselves or in a small group. At first, I felt as if I had not been a very good leader because most of my students were completely lost. I realized if I was going to make inquiry-based learning happen in my classroom, I would have to give my students more structure and support.

Change of Practice
The next unit, which dealt with electricity and magnetism, gave me an opportunity to adopt structures and support for inquiry-based learning. I knew I would have to model some parts of the inquiry process and provide more scaffolding in my instruction leading up to and during inquiry activities.

I showed my students a basic lab write-up that they would have to complete in three of their four inquiry activities. This helped establish clear expectations of what they were required to accomplish in the inquiry process and in their communications. I wanted my students to realize that inquiry wasn't just hands-on play time but an opportunity to make connections to the concepts we had covered in class. I wanted them to start reaching the higher levels of Bloom's taxonomy when reflecting on an inquiry process.

I decided to do four inquiry activities over the course of a few days, using a stations format. This format helped me allocate the limited materials I had for two of the inquiry activities and allowed me to focus my observations on four larger groups rather than on seven four-person groups. Letting my students work in teams led to valuable observations. I modeled the inquiry process with the first station, where the students did most of their lab write-ups. I essentially started the inquiry process through written and oral communication of my actions and thoughts, and the students finished the process.

The students worked well in their six- or seven-member teams. They were used to working in small groups in other classes; I just had not been doing a lot of it in my classroom. The two classes I chose to observe for this study worked better in groups that were a little larger than the norm for lab groups. I placed students in two types of groups: One was mostly females with a few males, and the other was mixed gender. I did this to see if some of the gender stereotypes the students previously displayed could be overcome. Gender does matter in determining how students are grouped, but sometimes the results are better if we veer from what we know or have been taught.

When I chose inquiry activities for the stations, I paid attention to the background knowledge of my students, the resources available, and the conceptual relationships of the inquiry activities. Before doing the activities, my classes spent about a week going over the basics of electricity to build up their background knowledge. The stations all related to concepts that were covered in the chapter on electricity in their textbooks. The first station, which I modeled, dealt with static electricity. Two stations involved working with creating electrical charges to make a battery. One of these stations was set up to see if students could repeat Volta's experiment using some common household items and a voltmeter. The other station was designed to see if a lemon and a pickle could be used as natural batteries. The final station was about creating series and parallel circuits to power a light bulb.

Results: The Inquiry Process at Work
I learned the most from stepping back and writing down observations of how my two classes worked through the inquiry activities. I deliberately chose one class in which the boys were very eager to participate but not so eager to reflect on their participation. I chose the other class because many of the girls seemed to lack confidence in their

scientific skills. The girls would express themselves well on paper but often held back when it came to participating -- for fear of not being right.

The team that was mostly girls relied heavily on the two boys for leadership. At the “natural batteries” station, most of the girls just sat back until a boy named Tyler got the group to start manipulating the materials. If Tyler hadn’t done this, I am not sure whether the group would have gotten anywhere. The same class had a team with only one boy on it, who sat back instead of taking a leadership role. I observed that the boys in this class often took the lead and were less threatened when they were not alone.

In my other class, I also observed teams in which boys took the lead and got their team started at each station. The teams in this class were more mixed-gender. One particular team caught my attention as they worked through the stations. The boys would go ahead and do the manipulatives first while the girls wrote down the boys’ procedures and data. Then, the girls would follow the procedures they had written down to ensure the inquiry activity could be repeated, and that the data collected was accurate. In this instance, gender differences actually worked to the group’s advantage.

Of course, I made some observations that reinforced some of the typical gender stereotypes. I noticed that boys on some of the teams were playing too much. They were reprimanded by the girls, who wanted them to focus on the inquiry process. The boys on these teams immediately began generating ideas for extensions to the activities while the girls were more worried about completing the task of a lab write-up and having a finished product. I also saw how culture affects the way gender differences play out. In one group, a girl named Norma looked confused and told me: “I don’t know how Carlos got to that point.” “Why don’t you ask him?” I said to Norma, forgetting that women in many cultures have been taught not to disturb men when they are working.

Overall, the boys’ writing improved and became more complete while the girls’ participation increased. Ironically, both of these effects resulted from adherence to gender roles. Two girls in particular demonstrated how gender plays a role in finding the best instructional methods. A girl named Sandy, who ordinarily didn’t participate, really got into building the series and parallel circuits. When I asked her about it, she said, “I feel like I am really accomplishing something; I can see results.” Another student, Josie, told me that she now liked science because she felt that I encouraged her and did not let her down.

Consequences: Look Toward the Future

As I look toward next year, I know I will have to build girls’ “scientific stamina” into the grid for determining an inquiry activity’s level, according to the Schwab/Herron Levels of Laboratory Openness. These levels allow a teacher to determine the degree to which the students make decisions about various parts of a laboratory activity. The materials I received at Fermi National Accelerator Laboratories and the collaboration I had with peers in my study group have been a great help. Most girls need to feel confident enough to participate in inquiry experiences. This is one gender difference I need to embrace.

I plan on developing a rubric to assess “scientific stamina” for all my students, using a framework for developing students’ goals and strategies in Girls in Science (Chatman, Nielsen, Strauss, & Tanner, 2008). I will be using rubrics and collaborative groups for the assessment of inquiry processes.

Reading a chapter of Why Gender Matters by Leonard Sax, MD, PhD (2005), I learned more about why gender matters in the classroom and was reminded of some gender differences, specifically, that girls and boys have different perceptions of teachers. I learned that girls prefer a face-to-face approach during instruction while boys prefer a shoulder-to-shoulder approach. I also will keep in mind that girls often need more encouragement while boys often need a reality check.

Next year I plan to take a team approach to developing inquiry experiences, using feedback from other science teachers at my middle school. I would like to see assessments that focus on how students can apply science process skills and demonstrate their "scientific stamina." I will be encouraging the other teachers to use inquiry activities that are standards-based and evaluated by agreed-upon rubrics as common assessments at the various grade levels.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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Understanding Gender Differences in Middle School Math Learning, *by Nelson Campos*

Author Bio
Nelson Campos is a math teacher at Jefferson Middle School in Waukegan, IL.

Abstract
Middle school teacher Campos examines strategies that move girls in his classroom from passive and safe "good girl behaviors" to more confident performance in math. He describes strategies in action such as "Think-Pair-Share" and group discussions.

The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Body
I enjoyed junior high and high school and had fun throughout. When I reflect on those years, I can picture most of my classmates and my classrooms. Girls were always considered to be the "smartest" students and more dedicated to their school work than boys. This was true for all subjects except two — math and science!

Girls seemed to be shy in math and science classes, perhaps because these subjects require more hands-on work and logical thinking, in contrast to the critical thinking involved in subjects like language arts. According to Gurian, "testosterone, the primary architect of the male brain, is believed to create more and denser neural connections in the right hemisphere of the male brain, resulting in males' having increased resources for spatial reasoning, mental manipulation of the objects, gross motor skills, spatial-mathematical reasoning, and abstract spatial reasoning" (2008, p. 9).

Gurian's observation has helped me understand why, as my studies in math and physics progressed, and I entered the field of civil engineering, my classmates were mainly males. Math has always been my favorite subject because I find it more practical and sequential than other subjects and easier to grasp and apply.

After I switched careers to teach middle school math, I realized that I couldn't simply teach the subject but had to implement strategies to keep my classes from being boring. During my first year, I noticed that boys were participating more and getting better grades than girls, despite their failure to complete most of the assignments or to seem fully engaged with the subject. Girls, on the other hand, seemed very quiet and reluctant to participate in many of the classroom discussions, especially those involving the entire class. Nonetheless, they always completed their tasks and came to me for clarification on a one-on-one basis or, more often, in pairs or groups. I thought this indicated that I was doing a good job of reaching all my students. Little did I realize how my instruction affected gender differences in how boys and girls learn.

Early in the summer of 2008, I had an opportunity to join the Associated Colleges of Illinois' Science and Math Collaborative to discuss the important role that gender plays in math and science teaching and learning. I was lucky to be selected and became involved in monthly "meetings," in which math teachers from the same district gathered to discuss gender roles in the classroom. From these discussions, I realized my instruction was inadvertently failing to sufficiently motivate my female students in classroom participation and discussion. Most of my instruction replicated the high school and college classrooms that I had found so highly motivating. In other words, my instruction was not “girl friendly” because I primarily used examples, language, and pedagogy that connected much more to male than female students.

At this point, I was perplexed and reminded myself that the girls were doing well in my math class, collaborating in discussions, and “volunteering” to answer questions. I usually am a reflective person, especially when a lesson doesn’t turn out the way I hoped. And so I reassessed what I had been doing. I was eager to go back to my classroom and prove that I was not leaving out females in my instruction.

After going over the lessons, I realized that much of the text was male-oriented. The book’s examples either mentioned males explicitly or made connections to the male population, offering little or no connections for females. I scrutinized my lessons to see how inclusive they were and incorporated a lot of collaborative learning in my classroom, where most of the students sat in clusters or pairs.

A few minutes after introducing the lesson, I asked a question and invited the entire class to answer. The boys were not worried if their answers were right or wrong, and they were extremely competitive. Even if they had previously given a wrong answer, they kept raising their hands. The girls, on the other hand, did not raise their hands until I encouraged participation. Most of the time, they responded after I encouraged them, and then they gave correct answers. I could see in their faces that they were very worried about what others would think of them if they gave wrong answers. There was an obvious sigh of relief when I agreed with their answers. I concluded that girls participated when encouraged by teachers and because they wanted to please. Moreover, because my classroom emphasizes cooperative learning, I noticed that students were willing to share their knowledge and help each other, and that this setting was working well for both boys and girls. Thus the question remained: What strategy might I use to help boost the confidence of my female students?

With these observations in mind, I decided to design some questions to gather more information on the confidence levels of boys and girls regarding classroom participation and optimal learning environments. I knew that most of the boys felt very confident about participating in classroom discussions and volunteering answers, but the girls did not. After a couple of informal interviews with the girls, I discovered that the reason for their lack of confidence was the fear of being wrong and having other students make fun of them. When it comes to the best learning environment, both males and females agreed that they learned best by collaborating with a single partner or a group of four. However, the girls preferred the group to be female, while the boys did not care whether the group was male or mixed.

Now that I was positive that both males and females learned collaboratively, it was time to implement strategies that would promote greater student involvement and participation. After considering various options, I decided to go with a “think-pair-share” approach. Because the students were already sitting in clusters, I used “group discussion” activities. Both of these strategies allow every student to be involved in the classroom discussion and to receive positive feedback, both in the form of praise and points toward their grade.

Before these strategies were implemented, four boys and two girls consistently participated in classroom discussions. To prepare for group discussions, students were allowed to have informal preliminary conversations in small groups before they were asked to participate in discussions involving the entire class. Both boys and girls enjoyed getting involved in these informal conversations, but it was the girls who gained more confidence from them. I allowed them to discuss for two minutes; afterwards, I rewarded anyone who participated in activities involving the entire class. The reward made the class as a whole more competitive and girls more comfortable in participating. After two to three weeks of implementing this strategy, the number of students regularly participating grew from four to eight boys and two to six girls.

The think-pair-share activity also seemed to be effective in building the girls' confidence. In this activity, the students were required to work in pairs whenever I posed a question or problem. All students had index cards on which they wrote their answers and comments. Students had to work on their own for approximately two minutes before they were allowed to pair up with other students to discuss their answers. At this point, they had another two minutes to share their answers before class discussion. Again, the students were rewarded for participating, both with positive feedback and points toward their grades. This activity was more effective with the boys as their participation grew from four to seven, while girls' participation grew only from two to four. My explanation why think-pair-share failed to result in greater participation by girls is that girls who were paired with someone who wasn't performing well in the class may have had an increased fear of being wrong.

Overall, I think the new strategies that I implemented in my instruction were very positive and promoted more participation and involvement for both boys and girls. They surely helped boost the girls' confidence. Because of these experiences, I will be more aware of gender differences in my instruction and intend to implement more girl-friendly activities, while making sure I also maintain strong participation by the boys, as it is key for both genders to be engaged in classroom activities and discussions. Both strategies that I implemented also allow me to assess my students because I can easily walk around the room to observe who is participating and hear what everyone shares in groups or pairs. I also believe that I will build more confidence in my students by giving them more positive feedback and, more important, allow them to be rewarded for their participation in the form of points toward their grade.
The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

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Boys are From Mars, Girls are From Venus, *by Elvia Toledo*

Author Bio
Elvia Toledo is a teacher at Thomas Jefferson Middle School in Waukegan, IL.

Abstract
Middle school teacher Toledo focuses on assessing student confidence in both boys and girls and identifying the factors that might lead to increased confidence and student success. The activities described in this article were conducted under the auspices of the Associated Colleges of Illinois' Science and Math Learning Collaborative, an initiative funded by the Illinois Board of Higher Education's Improving Teacher Quality Grant Program.

Body
Research has shown that not only do boys and girls evidence different attitudes and behaviors, they also have different learning styles. This is especially true when they study mathematics. In my experience, gender differences have always existed in math classrooms. Girls appear to put their quiet masks on and do the assigned work, while boys jump out of their seats, excitedly yelling out answers.

To address these differences, I designed an experiment based on group collaboration, which attempted to increase the confidence and comfort levels of both sexes in learning mathematics. Many girls in advanced math classes feel just as nervous and isolated as I did when I began taking these classes at age 13. The experience of being surrounded by male classmates and a male teacher often makes a female student feel lost without her girlfriends.

As a student, I remember how the boys barely jotted down notes when the teacher explained how to solve an equation that was simple for them but not for me. The female students would write down every example, problem, and formula with our fancy pens and highlight key words or problems. Unlike the boys, we would always ask the “stupid” questions (as the boys would say), and we always had to study, although it seemed the boys never did. A few were labeled “geniuses” because they could grasp a math concept and learn how to apply it faster than anyone else.

My observations have led me to conclude that boys understand the world of mathematics differently than girls. As an educator, my goal is not only to teach math concepts, but also to encourage students to reach their fullest potential in this subject. Both as a student and an educator, I observed that boys and girls differ in their style and pace of learning mathematics. These differences are readily apparent when one compares their middle school math notebooks. Middle school girls are more organized, neater, and “fancier” about their math notes than boys are. Yet, they do not perform as well on exams as boys do. The idea that girls are teacher pleasers is also reflected in their notebooks because girls follow directions and go beyond just writing and solving math problems.

The gender gap is evident in class participation as well. Boys participate more actively in math classroom settings, while girls hold back -- allowing the boys to do all of the work. Girls frequently ask for reassurance while solving a math problem and want to know, “Is this right?” –they approach the chalkboard. In sharp contrast, boys run up to the board regardless of whether their answers are correct -- their “Mr. Showoff” attitude on full display. Boys also beg to play competitive math games, such as “Around the World” and “Holy Toledo,” while girls are more concerned with avoiding failure. “Losing in front of the class is too embarrassing,” a student Jocelyn Najera told me earlier this school year. Not surprisingly, women are less likely to choose math-based majors and careers (Science Daily, May 2003).

After meeting with my colleagues and reading widely on how gender affects math learning, I realized that female students need an extra boost of confidence in the classroom. They need positive role models who can help them build the confidence they lack so that they will feel just as comfortable presenting a math problem to their peers as boys do.

My project consists of reforming my classroom to allow more group collaboration. My goal was to help middle school girls take more risks and become more independent in their math studies. It also focused on encouraging middle school boys to ask more questions and become more conscious of their thought processes as they applied math and completed mathematics assignments.

The first step was designing a Math Personality Test to learn about my students' comfort and confidence levels. After reviewing the test results, it was clear that middle school girls lacked confidence in mathematics and preferred to sit in groups with their girlfriends. I also observed that my female students with strong backgrounds in math were not confident enough to go to the blackboard and demonstrate solutions to problems.

Michael Gurian (2003) argues that girls' voices can become lost in large groups, so I decided to add smaller group work to my teaching practice. I designed a curriculum that allows students to interact with each other when solving math problems. To facilitate interaction, I changed the set-up of my classroom, organizing students into groups of four. I hoped to see an increase in my female students' collaboration, participation, and confidence in applying math and completing assignments. During this project, students assisted each other in solving math problems, which also improved their math vocabulary. My quiet students, both male and female, were more involved, suggesting that group collaboration was beneficial to them as well.

Another innovation was designing a visual point system to reward students for their teamwork. Instead of calling on students randomly, I allowed them to work in their assigned groups to solve math problems. During this process, I circulated through the classroom, providing assistance and, most important, encouraging students to work in their teams to earn participation points. Then, using my "popsicle stick" method, in which names are written on popsicle sticks and randomly selected, I chose a student to present the team's solution.

Reciprocal teaching took place as students taught their peers. I asked questions of the presenters to make certain that they understood the material. I also had two students (a boy and a girl) grade the presenters' work, using the student grading criteria for ISAT's Extended Response Essays (math knowledge, strategic knowledge, and explanation effectiveness). This grading system deliberately requires students to show their work and explain their reasoning. This made boys more conscious of how they applied math concepts and completed math work. I also kept a paper trail and gave additional participation points to students who asked good, solid questions during presentations.

To cultivate a positive classroom environment, my graders were required to write positive comments and/or suggestions for the presenter's improvement. This, too, was translated into participation points for each presenter's team. Students were able to connect their participation points to their team's performance and see their updated grades every week, which introduced a sense of competition.

Along with the points, I awarded courage ribbons to the presenters. The students wrote on the ribbons why they felt brave in math class that day. Courage ribbons boosted self esteem by allowing students to reflect on their personal positive actions. I collected all the ribbons and designed a courage tree for show and tell. My students were excited and proud to see this six-foot tree outside my classroom because it represented them. I named the tree, Cultivating Courage, to symbolize our growing courage as a class while learning and applying mathematics.

At the end of my project, I administered my Math Personality Test again. I wanted to examine my students' feelings about the use of group collaboration, visible participation points, and evidence of their courageous actions as displayed in the hallway. In most classes, the averages for confidence and comfort levels increased for both sexes. Test scores also indicated that students liked sitting in groups and having the opportunity to help each other in solving problems. In addition, my students improved in showing their work, explaining their strategies, and asking elaborate questions in class.

Teaching is a learning process, and, throughout this project, I became more aware of gender learning differences in my classroom. Mathematics is a challenging subject to study, which is why the practice of “two heads are better than one” is so appropriate. I learned that female students need an extra boost of confidence and greater comfort levels to believe that they can be successful. Simply rearranging my class in groups helped effectuate this. Based on this study, I will rearrange my classroom to make it more student-centered, allowing students to share their mathematical ideas and problem-solving approaches. Openly distributing participation points also engaged students in my class and encouraged the quiet ones to discuss math.

I strongly believe, on the basis of my experience and data, that students learn mathematics more effectively when working in groups. Much can be done in the classroom to bridge the gender gap in learning mathematics and science. Group collaboration helps students gain confidence and build teamwork and group communication skills. It gives students increased opportunities to discuss the material and feel more confident about the results of their efforts.

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Chemistry 109: Learning About the Physical World, *by Elizabeth Fischer*

Author Bio

Elizabeth Fischer, a Chicago native, earned her bachelor's degree in chemistry at Lake Forest College and her Ph.D in chemistry at Northwestern University. Elizabeth taught at Barat College in Lake Forest and was Dean for Academic Affairs for seven years. Elizabeth began teaching at her alma mater in 1992 and for eight years served as Dean of the College, the chief student affairs officer. Currently, Elizabeth is serving as Senior Lecturer in Chemistry and is a member of Linking Learning Communities Project working with teachers in the Waukegan District 60 public schools.

Background

Many factors have influenced me as a student and teacher of science at Lake Forest College. These include the following:

1. I am the daughter of a woman physician who practiced for more than 50 years, was chief of the medical staff at an inner city hospital, and was a woman.
2. Many of my family members studied or were involved with science.
3. I attended a single-sex school from first grade through high school.
4. My chemistry teacher in high school was an experimentalist and a woman.
5. I attended Lake Forest College and majored in chemistry. The Chemistry Department typically graduated more than 50% women annually and continues to do so 30 years later. Most of the professors were men, but they delighted in all of their students succeeding.
6. I attended Northwestern University graduate school in which 30% of my class were women.
7. My teachers and professors encouraged my pursuit of my academic and professional goals, and my family never interfered with my decisions. My teachers helped motivate me and supported the development of my scientific and personal educational journey. From my learning environments – from K-12 and to college -- I always felt confident about pursuing science as a major interest.

Lessons Learned

I am an observer. I love to people-watch; I collect observations and use them as data. I studied my teachers and especially the environment they created in their classrooms. The lessons I learned are:

1. Accept each student as an individual with unique strengths and challenges regarding learning. This means that both female and male students have fears and loves about science.
2. Make the material accessible to students.
3. Discuss fears about science and math so that they can lessen in importance.
4. Use personal challenges to ensure that students hear that we all have difficulties as we learn.
5. Humor is a great teaching and learning tool.
6. Intellectual pursuits are very important, and acknowledging your academic being is essential to growing as a student.
7. Learning takes practice.
8. The classroom must be a safe zone. This means that the entire class as well as the teacher must take every question seriously. Respect the learning process as it happens.
9. Learning is evolutionary, and changes to accommodate the students need to occur.
10. All students begin with science differently, and where they will take the material differs. Meet them where they are, and help them develop the tools they will need.

Preparing for Chemistry 109: Learning About the Physical World, Spring 2007

As I began to think about the non-majors' science course "Learning about the Physical World," which is also cross-listed in Education, I wanted to construct a course that had practical outcomes for the students. The course was populated with elementary education candidates, as well as the general non-major student population at Lake Forest College. "Practical outcomes" for elementary education candidates meant gaining the ability to do science as a scientist does, find resources easily, and think as a scientist -- so that their future students would learn science from teachers who have experienced doing science, and, most of all, it meant lessening students' fears that they cannot do science. The course design included demonstrations that incorporate some hands-on opportunities for the students, class presentations, quizzes and exams, and maintaining a laboratory notebook.

The purpose of the laboratory notebook was twofold. First, the notebook served as a structured method of learning how scientists write observations, process data, and reach conclusions. So, it was a way to teach the scientific method. As such, it allowed students to begin to think about why and how they would use the notebook. Second, the notebook was used as a journal. Prompts were given, and students were asked to write one or two pages on their thoughts. Typical prompts asked students how they felt about being in this class at the beginning and three weeks into it. They were asked to write a lesson for elementary students on a scientific principle we had studied and to discuss the demonstration presentations that they were interested in making to the class and why.

Class size prevented every student from doing each demo individually. So I asked groups of students to present their demos as team efforts. We wrote down data from which we developed hypotheses; for every measurement I did, I had a student verify the measurement or do it himself instead of me. I modeled data gathering and drawing conclusions from the data.

The class went well, but I knew I wanted to make some changes for spring 2008. I covered too much material in the spring 2007 class, and there were too many quizzes and exams. On the more positive side, I felt that the presentations had gone well and that the students liked hearing from one another, rather than only from me. In discussion with Dawn Wiser, I realized that I could emulate her idea of letting the students have some choice of topics to study and present within the framework of the course.

Preparing for Chemistry 109: Learning About the Physical World, Spring 2008

For the spring 2008 semester, I added more presentation topics from which the students could select options within the course content. I modeled presentations and then asked students to work in groups — larger ones early in the semester and then smaller ones later. We discussed their evaluations -- conducting informal evaluations early on and more formal evaluations later. As we progressed through the material, I asked them to peruse the chapters we needed to study so they could pick topics they were interested in presenting to the class. They were asked to identify materials for these demos and make a list of references to use. I went through their choices with each group, made suggestions for the presentation, and added references if needed. In addition, I gave individual feedback to presenters periodically. This was critical in improving presentations for a number of students. The students grew in their ability to make effective presentations and reflected that they liked the idea of different presenters.

I maintained the lab book assignments for writing up the demos and journal entries. However, I I wanted to improve the use of the lab book in the future. I wanted to work on both the prompts and the feedback of the experimental observations that the students are making. My literature search on the use of lab books for science led me to a wealth of information from the Seattle School System Science Notebook Project, articles from a variety of sources on K-8 education, and a book by Betsy Rupp Fulwiler entitled Writing Science: How to Scaffold Instruction to Support Learning, Heinemann Publisher (2007). These sources were helpful in preparing to teach Chem.109 for spring 2009.

Goal For Chemistry 109: Learning About the Physical World, Spring 2009

My overriding goal for spring 2009 was to remove as much fear of science as possible from the environment and then make the course practical for pre-service teachers -- so that they will have a stash of tools to use when they teach on their own. I had two primary objectives to accomplish this goal:

1. Remove students' fear of science as an obstacle to learning

- Pick experiments that students can relate to: Allow them to see and do.
- Write in the lab book to confirm understanding and for readily available ongoing references.
- Provide choice in presentation topics after initial modeling.
- Use collaborative learning as a way to make the material less threatening.
- Do presentations collaboratively with at least two students for each.
- Ask students to think about thinking (meta-cognition).

2. Develop student — especially women students' — confidence with the material.

- Consider what it means to teach someone else: Don't pass on my fears to the next generation.
- Enable students to know how science works, so that they will feel empowered to set up any experimental situation.
- Discuss reflections about "doing science" while students are doing it.
- During the course, prepare resources that all students can take with them when they go out to teach.
- Award grades that reflect greater emphasis on writing in the lab book and presentations than on tests and quizzes.

The class was composed of 33 students — 23 female and 10 males — many who were athletes in football, hockey, and basketball. Six students reported that they were in teacher education or were thinking about becoming education majors. Many students were taking the course as a general education requirement. The class included four seniors, five juniors, 11 sophomores, and 13 first-year students.

Results

Spring 2009 was the third year that I taught this course, and I wanted to add more feedback loops about the presentations and the demos. First, I developed a student presentation evaluation sheet that students completed after each presentation to provide presenters with class feedback on their work. On one exam, I asked students the following five-part question regarding their participation in presentations and demos:

- Some would claim that participation improves learning. How do you see yourself as a participant in this class? Be specific.
- In what ways are you comfortable participating in demos/experiments? Be specific.
- In what ways are you uncomfortable in participating in demos/experiments? Be specific.
- In what ways are you comfortable in participating in presentations? Be specific.
- In what ways are you uncomfortable in participating in presentations? Be specific.

As one might predict, for the most part, students reported feeling comfortable with topics with which they were familiar and less comfortable with topics that were less familiar to them. After the exam, I made a point of telling the class that they need to be the ones to figure out how to become more familiar with the material, tools, and questions they need to use to discover the answers they are seeking. The laboratory notebook also served as a journal. Many of the issues students raised in their journals at the beginning of the class were addressed in the course goals:

1. Making connections with the material.
2. Being respected in the classroom.
3. Doing better in science than in previous science experiences.
4. Learning how to speak more effectively in public.
5. Fulfilling a general education requirement.
6. Being open to “trying science one more time,” even after having had bad experiences earlier in their science education.
7. Being excited about learning concepts of physical science, in spite of previously earning low grades in math.
8. Participating in a small class with students who also have had bad science and math experiences and who understand these fears; having numerous resources outside class who will offer help.

Students were interviewed at the end of the semester. Some of their comments follow:

1. Students reported positively on the hands-on and interactive nature of the class. Both male and female comments were positive.
2. Both male and female students reported a greater sense of confidence about science, four of twelve reporting an increase in their confidence level at the end of the course.
3. Many of the women liked the hands-on approach as a way of working with students with different learning styles as well as the social aspects of working in groups.
4. Students liked the idea of peer teaching via the presentations. Men indicated that they liked being responsible for teaching the material to their peers, implying they had a responsibility to do a good job for their peers.
5. Both men and women commented that they were pleased the course was highly conceptual and not “math heavy.”

As a result of the interview comments, I feel that I understand how to lessen students’ fear of science in this course and to use the presentations to help students to grow in their confidence. I think the lab write-ups were better this year because I modeled the process more transparently than in prior years. I also have observed students’ anxiety in ways that I am still processing, e.g., a male student who wanted to meet with me privately when no one else from the class would see him and a female student who literally became ill while looking at a sheet of chemical equations.

Future Work

I am anxious to compare notes with my science and math colleagues who have been working to strengthen teaching and learning in this area. I know I want to include some other assessments in class and get better at collecting data from the students while the class is in session. I need to continue to work on the journal aspect of the course and to use mini-assessments during the semester. I need to spend more time understanding the gender issues in my class. I am trying to create a classroom setting where all my students are comfortable, and I wish to assess more fully my attitudes and behaviors toward men and the women students. At the moment, I think my approach is primarily to work with the individual student in front of me in genderless terms. I have a hard time distinguishing what I do differently in teaching the men and the women in my class.

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Observing Gender Difference in a General Education Physics Course, *by Scott Schappe*

Author Bio
Scott Schappe is an Associate Professor of Physics at Lake Forest College.

Introduction
When my son was in the 5th grade, I invited his science class to visit me at Lake Forest College for a couple of hours. I gave a tour of my research lab, showed about a dozen demonstrations, and then we walked through the rest of the department. I wanted to give the kids a glimpse of what real science is about (hence, the lab tours) as well as excite them with the demonstrations, which I chose for the maximum "wow" factor.

For the last part of the tour, we walked through the upper-level optics laboratory in progress. The lights were turned off, and the room was dimly illuminated by the various instrument screens and reflected laser beams on the optical tables. The kids walked through the room in an almost reverential manner. Their enthusiasm and attentiveness reminded me that just about everyone at this age likes some aspects of science.

On the way out of the building, I was very gratified to hear one of the girls say, "When I go to college I want to study physics." I hope that this girl's enthusiasm for physics has continued. Girls' early interest in and aptitude for science and math often is not sustained through the middle and high school years, let alone into college. This is truer of physics and engineering than any other field. In 2001, 46 percent of students taking physics in high school were women, but only 22 percent of students who major in physics in college are women.

Here in the Physics Department at Lake Forest College, we have been more successful at recruiting and retaining women physics majors: since 1996 (the year I arrived at the college), 31 percent of our graduating majors have been female. I think that there are several reasons for our relative success: First and foremost, there is usually a cohort of upper-class women physics majors to set an example. Secondly, our majors (men and women) are a very supportive and cohesive group that spends a lot of time studying together in the Physics Department. Finally, the physics faculty is very enthusiastic about teaching physics and works very hard to make sure that all of our students can succeed.

But we can and should do better than 31 percent women among our graduates, considering that about 50 percent of students in the first-year sequence are women. I'd like to know if there are ways that we can increase the percentage of women who choose to major in physics. Equally important is the issue of what can be done earlier in girls' education to give them confidence in physics and maintain their interest in the field through high school. I hope that by studying my own methods I can offer some insights into these issues.

Questionnaire
In addition to the courses for our physics majors, I also frequently teach a general education course called "Light, Sound, and Waves," which is intended for non-science students. To a large extent, these are students who are not particularly interested in science and, indeed, many are fairly math/science-phobic, so they present a challenging audience.

I am constantly tinkering with this course in an attempt to make it more interesting and relevant, while somewhat faithfully representing the nature of physics to this audience. In addition to the choice of topics, to achieve these goals I have many tools at my disposal, such as lectures (short), labs, homework, in-class interactive questions, and in-class discussions. I have often wondered how to balance these to optimize student learning. The Associated Colleges of Illinois' *Science and Math Learning Collaborative* (SMLC) offered a framework to deal with some of these issues through the lens of gender. This project also has made me think more carefully about gender-related teaching issues, and I hope to be able to carry these new insights into all of the classes I teach. The spring 2009 “Light, Sound, and Waves” course had 29 students, 12 of whom were female.

One part of my study was an anonymous (identified by the gender only) questionnaire about preferred learning styles. I asked the students to rate these four activities in building their confidence and competence in the course material:

Q#		More helpful	Somewhat helpful	Less helpful	Unsure
1	Lecture				
2	In-class PRS questions				
3	Demonstrations				
4	Laboratories				

I also asked the students to rank themselves on the following 5-point scale regarding their study/work habits:

I prefer to work alone (1) to I prefer to work in a group (5)

I learn better by observing (1) to I learn better by trying things (5)

I prefer labs that have specific, well-defined tasks (1) to I prefer labs that are more open-ended and exploratory (5)

Results
I looked to see if there was any correlation with gender. For the first three questions, there is very little gender difference in the responses, except that one might infer that the men are slightly more skeptical of all three of these methods.

The fourth question shows a noticeable gender difference. Surprisingly, the men found the labs less useful, even though in Question 6 (below), they said that they learned better by trying things rather than by observing. Perhaps the labs are too "canned" for some male students, which I plan to investigate by making at least one future lab more open-ended.

Men and women were virtually identical on Question 5 about solitary versus group study. As one might expect from stereotypes, women self-report that they learn better by observing (Question 6), while the men say they'd rather "try things." This does not quite square with the results of question #4, ranking the usefulness of the labs. As to the nature of the labs, the women preferred well-defined labs, while the men were bi-modal.

Late-Semester Poll
I also polled the students later in the semester with some opened-ended questions. Ten men and 11 women responded. I asked the students several questions including: "Comment on the labs. Are they useful? Enjoyable? Tedious? How would you change them if you could? More exploratory (less "recipe-like")?"

Most students had little comment beyond that the labs were enjoyable and useful, but all three comments in favor of more exploration came from men, and all four comments in favor of the "recipe-like" approach came from women. This is somewhat consistent with the last question from the first poll, though none of the men who preferred "well-defined" labs cared enough to write about it.

I also asked the students to estimate the hours per week spent working on the course outside of class time. The 10 male respondents reported an average of 2.3 hours/week with a standard deviation of 1.2 h/wk. The women reported an average of 3.6 ± 2.9 hr/wk, although eliminating the 12 hr/wk outlier reduced the average to 2.8 ± 0.8 hr/wk. There could be several reasons for this difference: Perhaps the women are more conscientious or less confident and thus felt that they need to work harder.

Lab Observation
As another part of my study, Lake Forest College Professor Dawn Abt-Perkins observed one of my one-hour laboratories. There were eight lab groups of two students each. She observed that, in general, the men were more active working with the apparatus, and the women fell into the role of readers of instructions and transcribers. Obviously, in single-sex female groups, at least one of the women had to become the "doer."

Professor Abt-Perkins made two additional observations: First, the men don't talk as much as the women and are reluctant to seek outside help to solve their problems. Second, she observed that I interact somewhat differently with men versus women. I tend to give women more specific answers and manipulate the equipment myself, while I tend to give the men more open-ended answers, and they do the physical work themselves. This may be due in part to the fact that the women ask better-formulated questions, and the men are quick to grab the equipment. Regardless, I need to be aware of this asymmetry and work against it.

Conclusions and Future Work
Clearly, the numbers in my study are too small for any firm conclusions. I am continuing this work in my current (Fall 2010) Physics 106 course, which will double the number of respondents.

The laboratory is the component that demonstrates the largest gender differences, and that is the component on which I have been working on the most. As I mentioned above, I have tried to be especially vigilant about interacting with men and women equitably: giving equally directive (or open-ended) answers and waiting for a member of an all-women group to manipulate the equipment or encouraging the women in mixed groups to work with the equipment. I also have made one of the four labs more open-ended. Polling the students after a mixture of lab types near the end of the semester may provide more evidence regarding the gender differences suggested here.

Naturally, this work also has raised more questions; "How does playing sports affect women's academic confidence?" and "Does it also affect preferred learning modes?" Also: "Do women athletes have more confidence in the lab, and are they less inclined to like well-defined labs?" I plan to extract this information in future polls. I suspect that female athletes have more confidence, but I'm unsure of their preferences regarding the prescriptiveness of the lab instructions.