Equitable Pedagogy in the Urban Classroom

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Introduction

Female students' academic achievements, perceptions, and attitudes toward mathematics and science are subjects that have received considerable attention from the educational research community for more than two decades (Tolley, 2003). Government entities, colleges, universities, and K-12 systems have worked on many fronts to address the disparities between male and female students in science and mathematics achievement, known as the gender gap. Systematic efforts have been made to reverse the negative attitudes girls have about science, technology, engineering, and mathematics (STEM). The negative attitudes girls have about these areas are one reported source of the gender gap.

Subsequently, STEM-based educational programs have been implemented to adjust the often skewed perceptions girls possess about mathematicians, scientists, and careers in similar fields. A myriad of science and mathematics programs have been designed to meet the special needs of girls. Even more pronounced are the instructional materials, teachers' guides, checklists, and computer-based resources that have been created to change the face of instruction to close the achievement gap (AAUW, 2004). The Women's Educational Equity Act (WEEA) Equity Resource Center is one such group that provides resources to the public. Like many other projects, the WEEA has been working on the equity front for more than 20 years (http://www.edc.org/WomensEquity).

One of the many efforts to remedy the gender inequity is the Sisters in Science Equity Reform Project (SISERP). Funded by the National Science Foundation (NSF) for over ten years, the project focuses on the diversity inherent in learning through various tools by which scientific and mathematical principles can be explored, analyzed, and communicated. SISERP houses six innovative science programs designed to foster gender equity and inclusion in science, technology, engineering, and mathematics (STEM) education: Sisters in Science (SIS), All Sisters in Science (ASIS), Sisters in Sports Science (SISS), Sisters in Science in the Community (SISCOM), Information – Sisters in Science Career Opportunities Matter (iSIS.com), and Sisters in Science Dissemination and Outreach Program (SISDO). The primary goal of the SISERP programs is to provide urban school aged girls with access to meaningful STEM instruction in an environment unencumbered by the restrictions of stereotypical practices regarding gender.

Science Education and Gender Inequity: Decades of Reform

Government actions such as Title IX of the Education Amendments Act, passed in 1972, have been enacted to address the inequities in educational programs receiving federal dollars. Subsequently, in 1974, the WEEA was passed. It expanded math, science, and technology programs for female students. In 1994, a package of gender equity provisions was included in the Elementary and Secondary Education Act. The provisions included the creation of teacher training activities that worked to eliminate inequitable practices and to develop programs to increase girls' participation in science and mathematics. In turn, monies from these various forms of federal legislation provided funding for the SISERP.

Reform in science and mathematics education has been on the national agenda for more than two decades. Research from the NSF (1990) and the Task Force on Women, Minorities, and Handicapped in Science and Technology (1989) noted that although efforts had been made to narrow this gap in achievement, little change had been realized. The consensus was that the methods for equitable practice must be embedded into the reform initiatives to ensure that all students were given the best possible chance for success. The national reform movement trickled down to state and local boards of education through the development of state and local science and mathematics curriculum standards, advocating specific content and equitable education. As schools searched for the best models of instruction to help teachers become effective, they incorporated the standards into their curricula. School administrators had little disagreement about the need for reform, but they differed on the specific modes to achieve reform. However, a commonly agreed upon theme for reform was the active involvement of learners.

Decades of research on science education and gender equity suggests a number of reasons and remedies for gender inequity in STEM education. For many years, science education reforms focused on changing the curriculum, teaching, and assessment of K-12 education to make for a more equitable learning environment (Tolley, 2003). Science education classes and expectations have excluded girls, leading to lower participation and achievements. Teachers' beliefs about students' abilities also were found to affect the manner in which female students operated in the classroom. In addition, it was noted that a female student's own perceptions of science also contributed to inequity in achievement (Tolley, 2003). Other avenues of inquiry demonstrated a lack of pre-service and in-service teacher education curricula focused on equitable pedagogy in the STEM classroom.

During the early stages of reform, published research concentrated on the science classroom environment. Studies conducted during that era suggest that in traditional and non-traditional STEM classroom environments, male and female students received very different educations (Hammrich, et.al., 2000). Specifically, the National Science Education Standards emphasized the "development of environments that enable [all] students to learn science that provide equitable opportunities" (National Research Council, 1996). Reformists believed that gender-sensitive classrooms were essential. These classrooms would include fostering a safe and nurturing environment, promoting problem-solving skills, building math confidence, displaying images depicting females in STEM-based careers, creating collaborative experiences, using hands-on learning, and allowing for open discussion about gender stereotypes.

Throughout this period, constructivism, an epistemological perspective of knowledge acquisition, served as the foundation for many of the noted suggestions regarding gender-sensitive science education. *Science for All Americans* (1990), a groundbreaking report by the American Association for the Advancement of Science, set new standards for science, mathematics, and technology education. It was also recommended that students be able to express themselves in oral and written form, work in teams, solve problems, question, explore, discover concepts, use authentic tools, and learn about related professions and contributions to the STEM field (Driver, 1995). Constructivist theory was also parlayed into the training of science educators. Accordingly, teachers were asked to model attitudes that fostered inquiry and knowledge and to seek ways to connect science learning to other disciplines (Richmond & Neureither, 1998).

In addition, it would be important to acknowledge the contributions and barriers of women in science and to use female-appropriate teaching strategies, showing careers in mathematics and science as interesting and relevant (Sanders, 2002).

Gender Equity in Science Education: The Current State

Presently, the U.S. Department of Education is launching a series of exams in reading and mathematics to assess student achievement in an effort to increase the status of American students in an ever-increasing global marketplace (U.S. Department of Education, 2004). Furthermore, policymakers, scientists, and mathematicians have focused on change to develop the scientific and mathematical knowledge that will produce a healthy economy and maintain a meaningful democracy. No less significantly, President George W. Bush's No Child Left Behind Act has been designed to increase student achievement. In an effort to realize this goal, the federal government has committed to closing the achievement gap by improving teacher quality and implementing effective educational programs. Most recently, funds have been made available for the professional development of pre-service teachers (U.S. Department of Education, 2004). Educational programs endorsed by the No Child Left Behind Act are based on the results of effective rigorous scientific research.

Systemic reform must remain on the national agenda if this nation hopes to attain the goals posed by the federal government. It is important to recognize, therefore, that the conditions of many urban schools and the communities to which they belong are appalling (Kozol, 2000). Lifelong learning in science, mathematics, and technology is impossible when female students in urban school systems have no access to the World Wide Web and have fewer textbooks, manipulatives, and science equipment than suburban students. In particular, females, minority students, and students from low socioeconomic backgrounds confront great structural challenges in choosing and performing well in the science, mathematics, and technology fields (Hammrich et.al. 2000, Schnorr & Ware, 2001).

For students and teachers with limited access to science exploration, innovative programs must provide an opportunity to examine hands-on science with the newest and most advanced science, mathematics, and technology resources. An awareness of cultural differences, including learning style, and relevance to real-world experiences are essential to the format, organization, and content of an effective program (Nieto, 2003). A current view of how individuals receive and process information proposes several independent forms of information processing including logical-mathematics, linguistic, musical, spatial, kinesthetic, interpersonal, and intrapersonal (Gardner, 2000). Based on this notion of intelligences, effective education needs to be diverse in its offerings, both in terms of content and format of instruction.

Challenge: Barriers of the Mind

While legal barriers to achieving gender equity in American society have been removed, many barriers still stymie females. Shirley Malcolm of the American Association for the Advancement of Science (AAAS) stated in her keynote address in 1997, to the American Association of University Women (AAUW) on Girls Succeeding in Science, Math, and Technology: Who Works and What Works:

"The effort to equalize educational opportunities for girls is far from complete… Unlike some other nations, female students in the United States are legally guaranteed access to math and science courses. While our legal barriers to this education have been removed, there are often still barriers we face; these are 'barriers of the mind'."

What are these "barriers of the mind" that prevent females from pursuing academic and professional careers in science, mathematics, technology, and engineering? They include the organizational structure of scientific and mathematics instruction, as well as females' perceptions of science and mathematics courses. Other barriers stem from societal influences such as parents' and teachers' lack of encouragement, authority figures' attitudes toward science, and the lack of support for females in science-based careers (Northrup, 2003). Researchers believe that fostering a safe and nurturing environment, promoting problem-solving skills, creating collaborative experiences, educating teachers, offering hands-on learning tools, and allowing open discussion of gender stereotypes are essential for encouraging female students' success in technological fields.

The organizational structure of current science instruction plays an important role in diminishing the resilience of females in science. Historically, science education has been taught as a competitive and individualistic discipline. Science instruction and science-based professions have been viewed as isolated enterprises that are objective in nature (Clewell & Campbell, 2002). The underlying discernment is that the barriers girls face in science often overshadow the very characteristics girls hold that promote their resilience in the actual practice of science, including seeking personal relevance; working cooperatively; valuing interdependence; and having keen observational, verbal, and writing skills (AAUW, 2000).

Challenge: Gender Gap and Science Education

The first hurdle that girls face is being born female. Research studies have documented the wide gender gap in achievement scores between males and females in the areas of science and mathematics (NSF, 2000). The authors of this research assert that when girls are allowed to work in a manner intrinsic to their collective learning style, appropriate science and mathematics learning takes place. Such concerns have laid the groundwork for the SISERP intervention programs, which specifically target females in order to increase their success in science and mathematics by providing access to gender-related teacher professional development, classroom materials, and curricula to maximize a gender-equitable approach to science education.

Increasing evidence also shows that the gender gap in science may be better understood in terms of the supposed masculine nature of STEM related disciplines. Therefore, assigning STEM disciplines a masculine moniker impacts the learning styles of females and the current instructional patterns of teaching STEM in classrooms around the world (AAUW, 2000). The assertion is that the general learning style of females does correlate with the manner in which science is presently taught. However, the research does not support this assertion.

Researchers have reported that girls and boys have vastly different formal and informal science experiences that contribute to the gender gap in science achievement (Linn, 1990). Indirect and direct experiences that contribute to such differences (Kahle & Meece, 1994) include:

- Entertainment choices, such as playing with science-based toys and games and being exposed to science fiction movies and television shows.
- Participation in science activities at home.
- Taking science-related field trips.
- Exposure to stimulating classroom instruction.
- Stereotypical behavioral expectations held by authority figures, including teachers, parents, and others in the general public.

Despite having preparatory experiences fairly dissimilar to boys, some girls succeed academically in science regardless of the hindrances they face (Richardson, G. et.al. 2003).

Challenge: Gender Bias and the Education of Urban Teachers

In addition to gender, race, and quality of education, another challenge female students must overcome is the effect of classroom teachers' perceptions of gender. Throughout world history, gender bias has been a problem that many women have strived to surmount. While women work hard to conquer gender bias in all aspects of daily life, female students continue to struggle against considerable gender inequities within the educational system (Jones, et.al., 2000). Stereotypical practices concerning females and males are second nature to many members of our society. The notion that "girls do this" and "boys do that" is deeply entrenched in the American educational culture.

Unfortunately, very few in-service and pre-service teacher education programs spend significant, if any, time on gender and the classroom. On average, pre-service teachers participating in teacher education programs spend less than 2 hours per semester discussing issues surrounding gender equity in the classroom (Stilles, 2002). With this in mind, it is highly important that gender biases in the classroom are dispelled through heightened awareness and education in the "best practices" for gender equity. Current research on gender equity and the classroom has shown that the first step toward gender equity in classroom teaching practices is self-evaluation. In order for teachers and school administrators to promote gender equity in the classroom, educators must be conscious of their own gender biases (Jones, et.al., 2000).

Females receive less attention from teachers, and this attention tends to be more often negative or contradictory. For instance, females may receive criticism for the content of work completed, yet praised for the neatness and the timeliness of the work. Males on the other hand are more frequently rewarded for intelligent answers and innate ability. Content is praised and appearance of work is criticized. This classroom practice leads female students to doubt themselves and their abilities, which leads to less participation in class and results in lowered self-confidence and underachievement (Sadker & Sadker, 1994).

If young Americans are to have options for their future education and multiple career choices in their adult lives, it is vital that veteran educators, school administrators, researchers, and academicians alike accept the challenge of ensuring that all students in the country have access to quality education. Furthermore, science educators must provide students with exceptional experiences that enable them to excel in the areas of science, technology, engineering, and mathematics (STEM). Undoubtedly, classroom preparation and the expertise of teachers correlate with the academic achievement of students.

Significant advances in research on the relationship between cognition and effective teaching contribute to a much-needed understanding of the value of continuous teacher education. Wang and Walberg (2001) reported that a poll, published by The New York Times, found that 80% of teachers do not feel prepared for instruction in the classroom. Additionally, a large number of teachers are not confident in their ability to overcome the challenges that they face on a daily basis. The first step toward the reform of teacher professional development in STEM education is to develop an effective teacher education program based on extensive scientific research.

Teacher experience and preparation have proven to constitute the most important variable determining what students learn (California State University Institute for Educational Reform, 1998). As evidenced by the achievement scores of students in urban school systems, the design and implementation of in-service and pre-service teacher education programs is disorganized and failing teachers as well as the students they serve. Unfortunately, experienced teachers, who are in huge demand, are unequally distributed throughout the public school system (California State University Institute for Educational Reform, 1998).

As a means to reform current teacher education, President George W. Bush’s No Child Left Behind Act has allotted funds for the professional development of teachers in order to increase student achievement. In an effort to realize the goal of improved teacher quality and professional development programs, the federal government has committed to closing the achievement gap by enhancing teacher quality through the development of effective teacher education programs.

Therefore, the professional development of inner-city teachers is crucial to the STEM achievement of K-12 students in urban school districts. Large numbers of teachers at inner-city schools are not at all prepared for teaching STEM-based courses in K-12 classrooms. In many inner-city school systems, less than 50% of math and science teachers are licensed and have an advanced degree in their area of expertise (California State University Institute for Educational Reform, 1998). This practice must change if students from inner cities are to realize academic and professional achievement in the areas of science, technology, engineering, and mathematics.

As proposed by Tharp, Estrada, Dalton, and Yamauchi (2000), five standards are necessary to the improve achievement of students from culturally, ethnically, and economically diverse backgrounds. The Five Standards of Effective Pedagogy and Student Outcomes are:

- Teachers and students producing together.
- Language and literacy development.
- Making meaning by connecting schools to students’ lives.
- Teaching complex thinking.
- Teaching through conversation.

Research findings show a consistent, positive relationship between classroom implementation of the five standards and an increase in student test scores (Doherty et.al., 2003).

SISERP Programs: Meeting the Challenges

Over the past 10 years, the Sisters in Science Equity Reform Project (SISERP) has focused on two major obstacles preventing equity in science education. As evidenced by 10 years of research in the area of equity in science education, the gender gap and gender bias in the classroom tend to inhibit females from exploring careers, both academic and professional, in the sciences. SISERP was established in the interest of providing equitable avenues for all students to pursue academic success in STEM disciplines. Incorporated into the six components of SISERP are comprehensive science curricula based on national standards, thorough gender equity focused professional development for pre-service and in-service teachers, family education programs, informal and formal science explorations, and educational components such as Saturday academies, summer camps, and after-school programs. The SISERP components are intended to reach underserved females in numerous capacities.

The premise for the SISERP lies in the continued under-representation of women and minorities in STEM fields. Over the past several decades, women have made considerable progress in narrowing the gender gap in STEM-related fields, but gaps persist. Statistics from the National Science Foundation (NSF, 2000) revealed that in 1997 "[w]omen constituted 23 percent of the science and engineering labor force,". Although females now account for half of all science and engineering bachelor's degrees earned, their share of bachelor's degrees in computer science has decreased from 37 percent in 1985 to 28 percent in 2001 (NSF, 2000). African Americans and Latinos are earning fewer science and engineering degrees relative to their population than do whites (NSF, 2000).

Sisters in Science (SIS) is the first program developed under the SISERP umbrella. The SIS program is a multifaceted educational intervention aimed at increasing young urban girls' interest and achievement in the sciences. The program has been designed to encourage positive attitudes towards science. Program components include an after school program, teacher training, family education and summer camp.

Daughters with Disabilities (DWD) was created to address concerns about girls with disabilities in elementary public schools who are widely underserved in inclusionary settings and undereducated in the areas of STEM. A critical outcome of such poor STEM educational experiences is the negative way that students with disabilities perceive science and math -- either they have no further interest in these areas or they are denied the opportunities to pursue further education because of their limited or non-existent knowledge base. Through the professional development of hundreds of special education teachers both pre-service and in-service, the utilization of mentors, and the creation of a family education program, the project has a direct impact on students, teachers, parents, and the STEM curriculum.

Sisters in Sports Science (SISS) is unique in its use of sports as a vehicle for science exploration. The program provides hands-on, inquiry based sports science activities that allow girls to develop a repertoire of experiences, which can then be used as the foundation for learning scientific concepts. Girls participating in the program are engaged in STEM activities that are fun, creative, and promote scientific literacy and career awareness. The program components provide girls with a structured, yet free-choice learning environment that meets their developmental needs for learning science and increasing their self-esteem, while at the same time enriches their formal learning experience.

Sisters in Science in the Community (SISCOM) project creates a much needed link between science educators and community/faith-based organizations. The program has been able to engage adolescents and their families in STEM activities during non-school hours. By fostering a supportive network among the university and community/faith-based organizations, SISCOM bridges formal and informal science education. Through a comprehensive hands-on, inquiry-based curriculum, program participants can take their heightened awareness in the sciences into the classroom.

INFO-Sisters in Science Career Opportunities Matter (iSIS.COM) program is an intense science program for urban high school girls. Combining technology, hands-on science explorations, and a yearly research project, the girls are introduced to a wide number of STEM related careers. In an effort to promote awareness, the program teaches the girls the different aspects of scientific research. This 3 year intervention matches the girls with females in science based careers. The scientists guide the girls through the process of research and completion of their project.

Sisters in Science Dissemination and Outreach Project (SISDO) sponsored by the National Science Foundation, has been developed as a clearinghouse for information critical to the reform of equitable teaching practices in STEM education. The dissemination project provides teachers and researchers with research based information promoting the "best practices" in a movement toward gender-equitable science education. Not only does the program support various publications specific to gender equity and science education, it also sponsors a yearly national conference and monthly gender equity focused professional development opportunities for classroom teachers.

New Visions for Gender Equity

The research on the achievement gap between the genders is mixed. The nation's academic profile is defined by the results of the National Assessment of Educational Progress. The Nation's Report Card (Braswell et al., 2001) stated that for mathematics, male students had higher scores than female students in Grades 8 and 12. However, the difference between male and female students in Grade 4 was not statistically significant. In addition, female students gained ground with respect to achievement between 1990 and 2000. The report also addressed perceptions and attitudes about mathematics. The report found that students who agreed that they liked math and that math was useful for solving problems scored higher at all tested grade levels.

In the area of science, achievement gaps were apparent and widening in Grades 4 and 8, whereas no significant difference was found in Grade 12. More encouraging was the finding that constructivist-oriented instruction implemented regularly, particularly in the fourth and eighth grades, produced higher average scores (National Center for Education Statistics, 2002).

Studies based on other standardized tests (e.g., the SAT-9) came to different conclusions about gender and achievement. Female students had higher math scores until Grade 9. Male students had higher science scores across most grade levels (Sanchez, et.al., 2000). Although there is evidence that the achievement gap has seemingly been addressed, it is also important to note that it has happened at the hands of the nationwide gender equity reform movement. Today, the standards for science, National Science Education Standards (NSES) and mathematics education, National Council of Teachers of Mathematics (NCTM) address not only student learning but content-area pedagogy, assessment, teacher training, and community development. Also of note is the fact that federal, state, and local initiatives continue to be designed and implemented to move not only female students but all Americans forward in mathematics and science. The authors of SISERP feel that the project stands as one of many gender equity reform initiatives that have had an impact on science and mathematics learning.

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