A Model University Program to Inspire Women in Science and Engineering (WISE)

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Abstract:

The WISE Program was a four-week schedule of classroom instruction and academic enrichment activities designed to increase mathematics, science and reading test scores for 8th grade girls. The program was designed to cultivate science, technology, engineering and mathematics (STEM) interest in young women by increasing their learning through critical thinking and problem-solving applications to pursue engineering and science careers. The program's focus was on fifteen (15) Baltimore City School 8th grade girls who were preparing to enter Baltimore City High Schools. The intent of this program was to further the mission and goals of the funding agencies education division and inspire minority women to pursue career paths in science, mathematics, computer science, engineering, education or seek professional employment. During the four-week period the girls were engaged in exercises and activities that cultivated their research skills. The girls also showcased their research projects and technology skills through a PowerPoint presentation recapping their summer experience. The classes, workshops, seminars and presentations were conducted on the campus of a Historical Black College and University (HBCU) in Baltimore City. The coordination and instruction took place under the guidance of the Center for Excellence in Mathematics and Science Education in the School of Education (CEMSE) at the HBCU. The WISE Program was supported by funds from a federal agency grant Network Resources and Training Sites (NRTS).

Introduction:

Designing an academic enrichment program for girls was prompted by the vast amount of research and anecdotal evidence that suggested girls are not traditionally encouraged to pursue careers in STEM. The mental image of a "computer geek" is rarely a female. It was anticipated that girls could be encouraged to embrace science and mathematics, thus erasing the traditional "geek" image and discouraging girls from associating high achievement with a negative image or a specific gender. According to the "Keys to Math Success," a report prepared by the Maryland Mathematics Commission [1], African American students not only have significantly lower levels of performance overall, but their performance declines slightly between fifth and eighth grade. In Tables 2 and 3 male students in Maryland scored significantly higher than females. Table 1, on the SAT mathematics assessment, mirrors the gender difference indicated in national data [2]. The 2011 Maryland School Assessment (MSA) for Baltimore City 8th grade students in mathematics showed 33.7 % of students are proficient and only 32.4% were advanced [3]. For the 2010 High School Assessment (HSA) for 10th graders, 66% of students passed the Biology assessment and 66.9% passed the Algebra assessment [4]. The scores from the MSA in mathematics and the HSA assessments in biology and algebra are described in Tables 1, 2, and 3.

Table 1: 2010 College Bound Seniors, Maryland
Female Mean Scores by Ethiniticty

SAT	Test-Takers		Critical Reading		Mathematics		Writing	
Test-Takers Who Described Themselves As:	Number	Pct	Mean	SD	Mean	SD	Mean	SD
American Indian or Alaska Native	81	0	480	106	457	100	466	105
Asian, Asian American, or Pacific Islander	1,780	4	546	124	580	122	558	126
Black or African American	7,734	17	432	98	413	95	430	97
Mexican or Mexican American	185	0	484	99	472	94	482	101
Puerto Rican	148	0	511	92	490	94	510	96
Other Hispanic, Latino, or Latin American	1,065	2	476	105	466	106	483	108
White	12,272	26	537	100	528	99	540	102
Other	663	1	508	114	490	117	507	117
No Response	809	2	487	144	463	134	482	142
Total	24,737	53	499	114	489	117	501	116

Source: Maryland State Report Card 2010

Table 2: 2010 College Bound Seniors, Maryland
Males Mean Scores by Ethiniticty

SAT	Test-Takers		Critical Reading		Mathematics		Writing	
Test-Takers Who Described Themselves As:	Number	Pct	Mean	SD	Mean	SD	Mean	SD
American Indian or Alaska Native	103	0	496	102	477	110	457	97
Asian, Asian American, or Pacific Islander	1,830	4	538	122	609	119	540	126
Black or African American	6,143	13	427	99	429	103	411	96
Mexican or Mexican American	117	0	499	108	523	118	481	105
Puerto Rican	115	0	488	117	510	105	467	105
Other Hispanic, Latino, or Latin American	832	2	485	109	506	110	474	102
White	11,193	24	541	103	567	105	523	104
Other	476	1	521	118	533	119	502	117
No Response	824	2	484	144	487	151	464	138
Total	21,633	47	503	118	525	126	487	117

Source: Maryland State Report Card 2010

Table 3: Overall

SAT	Test-Takers	Critical Reading		Mathematics		Writing		Writing Subscores: Multiple Choice		Writing Subscores: Essay	
	Number	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male	21,633	503	118	525	126	487	117	49.0	11.6	7.1	1.7
Female	24,737	499	114	489	117	501	116	49.7	11.6	7.5	1.5

Source: Maryland State Report Card 2003-2011

A review and analysis of the Maryland Report Card from 2003 to 2011 showed the following results: 1) the MSA scores for all grade 8th female students in the state of Maryland who were proficient or advanced in mathematics was 13.1% - 36.8% [5]; and 2) the science scores for 8th grade females who were proficient or advanced from 2008 to 2011 ranged from 24.4% - 39.7% [6]. These scores are significantly below male students in the above content areas.

The WISE program helped girls increase their ability to score higher when they took the HSA test by providing interesting and fun instruction while developing basic algebra concepts in alignment with the Maryland Learning Outcomes. In addition, the program utilized innovative instructional strategies and the girls developed a science fair topic for which they could conduct research and could be used to develop a science fair. The intent of this program was to further the mission and goals of the funding agencies education division and inspire minority women to pursue career paths in science, mathematics, computer science, engineering, education or seek professional employment.

During the four-week period the girls partook in exercises and activities to cultivate research skills. The girls showcased their research projects and technology skills through a PowerPoint presentation recapping their summer experience. The program objectives included:

1. Strengthening the mathematics and science skills using constructivist classroom methods and instructional strategies;
2. Adapting the curriculum and lesson plans according to the students' multiple intelligence strengths;
3. Providing students with instructional technology to enhance learning through the production of a web page and a power point presentations of summer research;
4. Developing problem-solving and critical thinking skills of girls through mentoring and emphasis on increased understanding of mathematical concepts and scientific inquiry;
5. Preparing students to pass placement exams in order to enroll in honors mathematics and science classes within Baltimore City High Schools;
6. Helping students understand the benefits of a mentor partnership;
7. Developing ongoing mentor/mentee relationship with university personnel and professional persons through cyber-mentoring while in High School;
8. Increasing the participants' familiarity with the scientific process through the selection of a Science Fair topic and development of project methodology for presentation; and
9. Increasing the participation and academic success rate of girls in mathematics, science and engineering.

Background:

A number of state and local programs exist that target underserved students (e.g. Upward bound and Talent Search). However, few are gender specific. The need to improve indicators on the learning status of science and mathematics education of girls in middle and high school bridge programs remains a critical need. A variety of publications from the National Academy Press, public-private partnerships, Maryland State Department of Education, College Board, School Improvement in Maryland and other professional resources were reviewed. Based on literature reviews four basic themes remain evident: 1) there are inadequacies in the pre-college education of girls (this suggests that many U.S. students leave high school without adequate preparation in science and mathematics); 2) the inadequacies manifests in the lack of opportunities for girls to excel in technical careers, continuing education, and being informed citizens; 3) the problems facing the underserved population are some of the hardest issues facing educators and the least amenable to quick and easy solutions; and 4) although infrastructures are in place to identify what works in pre-K-12, higher education and the workforce, each level faces the same task of

how to identify and validate the effectiveness of programs developed to broaden the participation of women and underrepresented minorities in STEM.

Academic Enrichment:

The program was divided into a morning and afternoon session. Mathematics and reading instruction occurred during the morning sessions. The afternoon sessions provided instruction in technology development, science and scientific research activities. In the first few days of the program the science teacher provided an overview of various science disciplines and current mathematics research for students to select an area of interest. The remaining daily program activates included web page design and science fair project development. The science fair project areas covered Computer Science / Mathematics, Physical Science, Biological Science, Engineering, and Earth / Environmental Science. These topics provided ample opportunity for the girls to apply mathematics and science skills they developed to their science research topics. The participants are also exposed to a higher level of learning in a subject area in which they had little or no prior experience. The students then selected topics and begin their research in developing a science fair project for exhibition during the Annual Science-Mathematics-Engineering Fair. As part of the education enrichment experience the curriculum and lesson plans were adopted according to the students' multiple intelligence strengths. The student enhancement part of the WISE Program included activities to support the following:

Approaches to Learning	Instructional Activities
The application of visual/spatial intelligence	Language Arts - By reading (metaphors and analogies), writing, understanding charts and graphs, developing a good sense of direction, manipulating images, constructing models, designing practical objects and interpreting visual images.
To increase the girls verbal/linguistic intelligence	Speech - Cultivate public speaking skills (oral presentation of summer research at the closing reception) to think with words rather than pictures, listening to guest speakers, professionals and peer experiences, peer tutoring and teaching, appropriate use of humor, understanding the syntax and meaning of words, remembering information and analyzing language usage.
To enhance the girl's ability to use logical/mathematical intelligence	Curriculum Activities - The curriculum included activities that involved: problem solving, classifying and categorizing information, working with abstract concepts to figure out the relationship of each to the other, doing controlled experiments, utilizing the basic principles of experimental design and data analysis, questioning and wondering about natural events, performing mathematical calculations, and working with geometric shapes.
Activities to promote bodily/kinesthetic intelligence	Dance and Singing Activities - The girls showcased their dancing styles as part of the closing reception. In addition to dance other kinesthetic activities include:

	sports (swimming), hands on experimentation and the use of body language (modeling).
For those girls that are musical/rhythmic intelligence thinkers	Music-related Activities -The girls immediately responded to music either appreciating or criticizing what they heard. As part of the closing program musical selection were rendered.
Interpersonal Intelligence strategies	**Communication Activities - The girls envision concepts** from others point of view in order to better understand how they think and feel. They need to develop the ability to sense feelings, intentions and motivations. Exercises included: seeing things from other perspectives (dual-perspective), listening, using empathy, understanding other people's moods and feelings, counseling, co-operating with groups, noticing people's moods, motivations and intentions, communicating both verbally and non-verbally, building trust, peaceful conflict resolution and how to establishing positive relations with others.
As the girls move into the high school environment we want them to learn to utilize their own intra-personal intelligence	Personal Assessment Activities -It is important for students to evaluate and understand their inner feelings, dreams, relationships with others, strengths and weaknesses. The program encouraged the girls to recognizing their individual strengths and weaknesses, reflecting and analyzing themselves, awareness of their inner feelings, desires and dreams, assess their thinking patterns, reasoning with themselves and understanding their role in relationship to others

Activities:

Measurable Objectives	Achieved Objective
The girls took the Science Process Assessment for Middle School (SPAMS) and the Maryland High School Assessment 2002 (MHSA) for ninth grade students. The MHSA is a four-part assessment in: Mathematics, Government, Biology and English. The Pre- and Post test scores will be compared in order to develop a comprehensive portfolio of the girl's achievements.	The girls mathematics and science skills were strengthened using constructivist classroom methods and instructional strategies, this was facilitated through: a group learning approach, open discussion by posing questions related to a topic in context, hands on activities, writing exercises, critical thinking activities for mathematics, algebra theory and problem solving.
The students (girls) developed a web page chronicling their program experiences and presented their research in a PowerPoint presentation. The participants also, presented their research on a science fair topic of their choice using Microsoft Power Point software at the closing reception. The science fair topics were in the following areas: physical science, biological science, mathematics-computer science, engineering and earth-environmental science.	Students created a website displaying: their career goals, an abstract or hypothesis of their research and what they have learned in the WISE program. The girls were taught basic HTML and Beginning PowerPoint as part of their technology development. The students also had individual e-mail accounts to continue their cyber communication with fellow WISE staff and participants, mentors, tutors and University faculty.

Results:

Expected Objective #1: To increase the participants' skills in Science, Mathematics and Biology.
Measurable Objective #1: The 15 girl participants took the Science Process Assessment for Middle School (SPAMS) and the mathematics and biology sections of the Maryland High School Assessment (MHSA). The SPAMS assessment contained the science content areas the girls should have had previous to the completion of middle school (8^{th} grade).The total possible scores in each test area were: science 50, mathematics 38 and biology 53. The pre and post test scores were compared in order to develop a comprehensive portfolio of the girl's learning.
Achieved Objective #1: The girls science, mathematics and biology skills were strengthened using constructivist classroom methods and instructional strategies, this was facilitated through a group learning approach, open discussion by posing questions related to a topic in context, hands on activities, writing exercises, critical thinking activities for mathematics, algebra theory and problem solving. Increases in all areas tested were exhibited. The paired sample T Test, was used to compare the mean of the two variables. This test computes the difference between the two variables for each case, and tests to see if the average difference is significantly different from zero. The assumption was that both variables were normally distributed. The null hypothesis was that there was no a significant difference between the mean of the pre- and post test. The descriptive statistics for both variables are presented. The test shows that the mean for all of the post-test scores were higher than the pre-test scores.

Table 4 shows the Paired Sample T Test which is based on the difference between the pre- and post test variables. Note under paired differences the descriptive statistics for the difference between the variables as follows. The T values are: -4.435, -8.746 and -6.890 with 14 degrees of freedom (df). Our significance for this test the Sig. (2-tailed) Paired Differences which are: .001, .000 and .000. All of the Paired Difference values are less than .05, meaning there is a significant difference between the pre and post test scores.

Table 4: Paired Samples Test

Pair	Mean Paired Differences	Std. Deviation Paired Differences	Std. Error Mean Paired Differences	Lower 95% Confidence Interval of the Difference Paired Differences	Upper 95% Confidence Interval of the Difference Paired Differences	t	df Paired Differences	Sig. (2-tailed) Paired Differences
Pair 1 Pre Science – Post Science	**-2.86667**	**2.50333**	**.64636**	**-4.25297**	**-1.48037**	**-4.435**	**14**	**.001**
Pair 2 Pre Mathematics – Post Mathematics	**-6.60000**	**2.92282**	**.75467**	**-8.51860**	**-4.98140**	**-8.746**	**14**	**.000**
Pair 3 Pre Biology – Post Biology	**-4.60000**	**2.58567**	**.66762**	**-6.03190**	**-3.16810**	**-6.890**	**14**	**.000**

Expected Objective #2: To increase the participants' skills in the use of technology and comfort level through the use of practical application.
Measurable Objectives #2: The students developed a web page chronicling their program experiences and presented their research in the form of a power point presentation.
Achieved Objective #2: The students were taught HTML and power point as part of their technology development. Participants created web content that they added to a website created for the program. On the site you would find their career goals, an abstract or hypothesis of their research and what they had learned in the WISE program. The students also had individual e-mail accounts to continue their cyber communication with fellow WISE staff and participants, mentors, tutors and faculty.

Expected Objective #3: To increase the participants' familiarity with the scientific process and funding agencies mission and goals through the selection of a Science Fair topic and development of project methodology for presentation.
Measurable Objectives #3: The students were taught the scientific method and how to develop a research project.
Achieved Objective #3: The students presented their research on a science fair topic of their choice using power point software at the closing reception. The science fair topics were in the following areas: physical science, biological science, mathematics-computer science, engineering and earth-environmental science. In addition, the students presenting their research, a one page snap-shut of the content of their web page was included as part of their summer experience.

Conclusion:

The WISE program proved to be a successful approach towards inspiring minority women to pursue career paths in science, mathematics, computer science, engineering and education. The students were able to increase their skills in Science, Mathematics and Biology as well as their skills in the use of technology. In addition, through their research, they were made familiar with the scientific research process. The Science Process Assessment for Middle School (SPAMS) and the mathematics and biology sections of the Maryland High School Assessment (MHSA) served as program performance indicators. The results of these assessments indicated that this program can serve as a model for STEM development programs for girls. Tracking of the girls indicated that one-hundred percent (100%) graduated from high school or completed their GED. Seventy percent (70%) of the girls enrolled in a community college or four year higher education institution. The evidence of this project suggests that minority girls can make great strides in the pre-preparation for college through mentoring and through special academic enrichment activities specifically designed to address their individual needs. The program is clearly replicable with limited funding. Key to the success of this program was: 1) the proper assessments of individual educational needs; 2) quality mentors who took a personal interest in the girls; 3) tracking of girls through high school to college; and 4) quality instructional strategies that facilitated increasing their skills in STEM. The Director of the program was instrumental in following-up with the girls after the program concluded. This was important in motivating the girls to pursue college and STEM careers. The WISE program gave minority girls with diverse backgrounds an opportunity to be exposed to a college campus and experience

excellence in education in STEM careers, and have an opportunity to connect with female mentors, scientists, and professionals.

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