

**POSITION PAPER:
TRADEOFFS IN
CAPITALIZING ON PRE-EXISTING INTEREST
THE GEMS PROJECT:
GIRLS IN
ENGINEERING, MATHEMATICS
AND SCIENCE**

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1 The Project: Using Pre-existing Motivation

Vision and Significance: Climate Change and Career Awareness

We have just received funding for the career awareness and climate change intervention described below. The central idea behind the project is to find a domain in which post-ninth grade inner-city girls have an intense interest and involve the girls in a SEM project that centers on this interest. At this age girls are pressured by family, schools, peers and society to develop a concern with their roles as women by developing a concern with outward appearance. We have therefore developed a cosmetic design project as the focus of our intervention. With our guidance, the girls will design cosmetics by working in the labs in which we spend our professional lives.

Additionally, they will be paid well for their work, counseled by us and introduced to financially successful SEM women. To produce climate change, we, along with community leaders, engage the various adults in their lives and publicly acknowledge their achievement and potential.

This position paper is meant to spark discussion on the tradeoffs we encountered and the reasoning behind the choices we made.

1.1 Source of the problem: Why girls of color choose against SEM

We believe that the low participation of women, particularly women of color, in SEM careers may stem from a lack of exposure to these careers and identification of these careers as irrelevant to girls' lives. As to the sources, the formal classroom instruction and the informal interactions that support and develop students' interest, understanding and skills in science and math are either missing or inappropriate for this population of girls. Additionally, our own experience and relevant intervention literature point to three aspects of gender socialization within minority groups that may account for the under-representation of women in SEM: 1) girls' expressive ways of working, 2) the chilly classroom and null environment in educational settings, and 3) the lack of role models in SEM (Ethier & Deaux, 1990; Brown & Gilligan, 1992; Sadker & Sadker, 1992, 1994; Gagne, 1977).

These three socializing factors point out problems of climate; self-confidence; relevance; match with cognitive style and role identity; exposure; and opportunity. The objectives that result from these problems are described below along with our intervention plan.

2 The GEMS Program

2.1 Objectives

Given the goal of increasing the likelihood that urban minority girls will know of and choose among a wide variety of lives in SEM and given the factors which block this goal, we have set the following objectives:

1. Build on the girls' belief that SEM is a good thing and have them come to believe it is relevant to and attainable in their lives.
2. Increase positive attitudes toward SEM, where they are flagging.¹
3. Allow girls' cognitive style to come into play, while incorporating traditional SEM ways of working.
4. Provide opportunities to participate in SEM activities.
5. Develop an awareness of the breadth of SEM career opportunities.
6. Create a school, home and community climate conducive to choosing a life in SEM.

Below we discuss the program that derives from these objectives.

2.2 Program Format

An Overview of the GEMS program:

- We will bring one cohort of 96 post-ninth-grade minority girls into our labs each summer for each of the three years of the program.
- During the summer, we will work with the girls on a high-interest, cosmetic design project. (But see the anthropology point below.)
- The work will take place in our labs and will integrate biology, chemistry, biochemistry, and psychophysics.
- The lab work will be done in conjunction with a literature section called "Lives of Women" in which girls will look at their dreams, roots and opportunities.
- A major component of the project will be the design of a computer run, competitive small business. We have chosen to present the scientific goal within a business context so that these economically stressed girls will feel free to commit to the endeavor. For the same reason the girls will be well paid for their work on the project.
- Working with an anthropologist, we will look at ways in which body decoration in the girls' historical cultures has not been used to create stereotypes, but rather as a tool in the development of identity and self-confidence.
- The work environment will be designed to meet the girls' social needs.
 - The work groups will be small and non-hierarchical.
 - Goals will be shared.
 - Activities will be hands-on.
 - Discussions will support discovery learning.
- The environment will also increase their repertoire of responses to competition.
 - We will work on how to make their products competitive – long-wearing, with an up-scale appearance and a low manufacturing cost: We will introduce the girls to the "instrumental" view, within a safe environment.

¹The literature shows young women of color do have positive attitudes with respect to science, but this attitude decreases over the course of adolescence (Clewel, Anderson & Thorpe, 1992).

- We will work with a wide variety of community members, at the beginning and end of each summer and every month during the year for the 3-year duration of the project (but see Target Populations section below).
- Our goals here are to foster attitude change across the community.
 - To do so, we will design activities with ourselves, the girls, civic leaders (community office holders, high-level educators and civic activists), clergy, family (parents, guardians, extended family, siblings), school personnel (principals, department chairs, teachers and counselors) and peers (male and female).
 - * We will have the girls present their work at community and school events and receive public praise from respected community leaders.
 - * We will have respected community leaders discuss and encourage the girls' career aspirations in the presence of the relevant community members.
 - We will show the economic opportunities of a life in SEM. We will meet with the community and business women who have succeeded because of their SEM training.
 - We will provide career counseling to the girls and their families throughout the project.
 - We will have conversations about life as a woman in SEM, about the personal and professional successes that are possible and the common obstacles we have overcome.

2.3 Target Populations

The girls: We will work with 96 girls a year for each of the three years. The girls will have finished ninth grade, having received average grades in one of the two Camden high schools. The population is urban and minority, 65% are African-American, 35% are of Latina descent.

DISCUSSION QUESTION. Age-based vulnerabilities and population choice:

Thirty-three percent of Camden girls are lost from their school cohort between ninth and tenth grades. More broadly, data suggest the ninth grade as the time of greatest vulnerability. By working with girls at the end of ninth grade we have not entirely missed this period and we can track the girls into college choices (Armstrong, 1981; Fenema, 1974; Fenema and Sherman, 1978).

Nevertheless, there is growing evidence that interventions need to start in the lower grades. Is this true as a blanket statement? What interventions are most effective at what age? Where should limited energy and resources be focussed?

Their sisters: We will also involve one of each girls' younger sisters and then evaluate the effects of the program on them. We feel comfortable addressing this situation first. As to girls who don't have younger sisters, our current intervention gives us food for future work.

DISCUSSION QUESTIONS. Future research issues: What is the effect on brothers; or of putting boys through the program, so that they have women mentors²? What if the mentors are men, or if the classes are mixed gender?

Community members & Climate Change: In addition to the 288 girls and their 288 sisters, we will also work with members of their community. We expect each girl to involve two adult family members. (We use the term as a shorthand to include adults with a strong personal relationship.) We also expect

²In one of our womens' studies classes the men and women were asked to make a list of opposite gender mentors. The young men interpreted the assignment as a request to make a list of senior women mentors for their female peers.

to work with 5 school administrators, 6 teachers and counselors and 4 church and civic leaders.³ The intervention will focus on a total of 288 girls and 879 community members over three years – a total of 1167 individuals.

DISCUSSION QUESTION. Stipends: These girls must work during the summers. We at first thought a minimal stipend would be sufficient, but we also want to show, very concretely, that SEM will provide economic stability (the school board estimates that 85% of the students’ families are on welfare). We have increased stipends from the typical \$5.00 per hour to \$12.50 to allow science to be a competitive alternative.

But we are concerned that adults will feel disrespected if these young girls earn the highest wage in the family. This may unconsciously contribute to family feeling that girls do not belong in science.

2.4 Delivery System

During the year we will work mostly on “community factors” of climate change with respect to family (parents, guardians, extended family, siblings), school personnel (board of education, principals, department chairs, teachers and counselors), civic leaders (civic activists and clergy) and peers (male and female). In the summer we will work intensely on “personal or internal factors,” such as confidence and role conflicts, but continue our interaction with the community.

2.4.1 Summer Institute

2.4.2 Overview: Two weeks’ activities

We will begin the Summer Institute with a short, one-evening opening exercise, welcoming the girls and the adults to the program. At the end of the Summer Institute, we will hold commencement exercises.

A typical day

Schedule:

We will begin with a forty-five minute Anthropology session. The girls will then meet for a lab session with their mentor-scientist and teaching assistants. The labs will be comprised of work in chemistry, biology and material science. The GEMS will then break for a whole-group discovery-based discussion and synthesis session with their teaching assistants and the PI.

2.4.3 Working With The Mentors: Labs + Seminar Discussions

Work in the natural sciences and business is done in laboratories; work in biography and anthropology is done in seminar discussions.

We begin by presenting the section on women’s lives as it makes clear the foundation of our philosophy. We then go on to the labs, presenting a biochemistry exercise as an example. We finish with short descriptions of business and anthropology.

2.4.4 Biography seminar discussion: Lives of women

In this component of GEMS, girls read short biographies or view short films about successful women scientists, engineers, and mathematicians. They do in-class writings in response to what they have read and seen, and they discuss their ideas with the professor and each other.

³Projects SEED and MESA have found that viewing parents as “partners” contributes to the success of an intervention.

The sample exercise below is meant to be personal. It will allow girls to see how they can have a life that includes family and career. It also addresses typical obstacles and ways of overcoming, modeling ways in which dreams can be made into concrete, achievable goals.

A Sample Lesson

A. Curriculum

- Video. Jewels in a Test Tube: Biochemist Lynda Jordan
Lynda Jordan, Ph.D. biochemist working on unlocking secrets of a key enzyme vital to giving birth. An African American who grew up in Boston housing projects.
- Our lessons will focus on 3 three aspects of women's development as SEMs:
 - Dreams
 - Roots or Foundations
 - Obstacles and Pathways

B. Activities: Discussion & writing exercise

Sample: On Dreams.

- Imagine yourself able to achieve your every dream. Write down how it feels to have achieved your dreams. Imagine your surroundings, family, friends, work, social life, etc. Describe your life once your dreams are achieved. (Imagining success; building confidence)
- Group discussion: What categories do your dreams fit into? Which are the most important to you? What are common characteristics of dreams? What were Lynda Jordan's dreams? What is the difference between a dream and a goal? (turning desires into goals)
- Select one dream and write about it to someone you love or admire. (communicating and committing to goals)

Through the use of each scientific discipline, we pose and solve issues in cosmetic design. Because of space constraints we present only one biochemistry exercise .

2.4.5 Biochemistry lab:

**“The Things That Make Your Make-Up Look Great,
Twelve Hot Tips From The Lab.” or:
Composition of biological molecules**

I. Context, Rationale

In the biochemistry component we help the girls formulate questions that will aid them in designing competitive versions of their products. This forms a shared goal which is met through collaborative effort.

A. Curricular elements

The girls will handle biological materials that give the cosmetics their functional properties. They will also operate the computer-controlled instruments used in a laboratory setting. They will discuss basic chemical principles and tie them to experiments of interest. In this way we are engaging the girls in a scientific theory formation exercise, in that they will be forming and testing hypotheses and deriving predictions from results. They will also be given the opportunity to discuss their work and produce visual and written records to share with the community and bring to a science fair.

II. A Sample Lesson: The biochemistry of pigments

A. Posing a question – Building and evaluating a hypothesis:

One problem that makes consumers wary is the way an individual's skin can cause changes in product color that cannot be predicted by visual inspection at the time of application. However, because these changes are caused by the interaction of pH levels in skin and product pigment they can be predicted by optical spectroscopy. As a result, we will carry out a spectrographic analysis to make and use predictions about pH-related changes⁴. We ask what favorite lipsticks do or do not change when applied to each girl's lips. The experiment that bears on the question of this change follows: The girls will select bio-pigments from lipsticks; change the pH; look at the ensuing change and identify the least reactive of the pigments for skin of a given pH. In the course of addressing this problem we will work toward our underlying goal: The girls will learn some basic principles and methodologies of biochemistry.

B. Discussing and recording

We will pose questions to the girls concerning their initial enthusiasm and hesitations; the obstacles they encountered; and their paths around them. After discussion, the girls will write a brief report about what they did, what they learned and what skills they acquired from this exercise. The report will be incorporated into a science fair poster for use later in the year. The girls will use their end-of-session discussions to create their own agenda as a starting point for the next meeting.

DISCUSSION QUESTION. Competition/Collaboration. With respect to entrepreneurial energy within a safe environment, a cost/benefit analysis will be done in conjunction with one of the chemistry sections. The girls will have a chance to develop products which, while inexpensive to create, have an up-scale look. In the business plan, we will discuss the entrepreneurial aspects of strategically matching appearance and ingredients to beat out competing brands.

We have equivocal feelings about introducing an element of competition. We want the girls to have a wide range of life-strategies, but we do not want to lead them into a purely instrumental/aggressive mode. We hope to address these concerns with discussions about the uses of competition and the need to care both for oneself and others.

2.4.6 Anthropology seminar discussion: Meanings of ornamentation across time and place

I. Context, Rationale

In this component, the girls explore ways in which physical ornamentation is used in service of self-definition. The girls envision body decoration as rites of passage in the context of their historical cultures of Africa and Latin America. In these cultures one develops one's "paint" as a rite of passage in which a strong internal personal identity is developed and made visible.

In the context of whole and small group discussions, girls see slides and videos on forms of ornamentation relevant to the group vs. the personal; status and role(s) within a group; and conventions specifying gender constraints. The GEMS will have time to practice face-painting in a way that combines current and traditional use of cosmetics.

DISCUSSION QUESTION. Cosmetics v. Anthropology: Although there is a potential downside to a cosmetic design project if it is treated in a superficial way, we feel we can turn the table here⁵. To combat the possible message of gender stereotyping through use of cosmetics we added the anthropology section in which the GEMS will learn of traditional

⁴Mathematics, Science and Minorities, K-6 has also had kids work with everyday items.

⁵Saturday Science Academy and Mathematics, Science and Minorities, K-6, have both had success when choosing projects with personal appeal.

African and Latin American⁶ uses of facial and body decoration. In these cultures one develops one's "paint" as a rite of passage in which a strong personal identity is developed and made visible.

The typical view and meaning of cosmetics, in which a natural face is seen as needing cover-up or augmentation, may still outweigh the view we are presenting. Actual face-painting sessions at the institute may help, but we still have some concern.

2.5 Year-Round Program: Climate Change and Mentoring

After a girl has joined GEMS we will work with her and her community at least once a month for three years. Our in-year activities take place in the community and are designed to continue our counseling and mentoring of the girls. The girls will present their summer work and be acknowledged by leading community figures; we will collaborate with family and school on academic and career plan; women successful in science-based business will meet with participants. These activities are designed to turn the summer's work into long-term climate change for the community. Our approach here is to engage community members in our mentoring and advising activities. For example we foresee: A career planning meeting with a GEM and her dad in which our enthusiasm sparks his; a talk with a minister which expands his awareness of the girls' options; a community meeting in which this minister then talks to a GEMS grandfather and leads him to participate in her college choices.

Our interactions with the community rely on a number of previously established factors involved in attitude change. We have chosen community leaders with charisma and high credibility (Singer, 1979). Additionally, their support of GEMS will not result in personal gain. These figures have also been chosen to match the ages of sub-groups of community participants to decrease the possibility of generational mismatch (Sears, 1979, 1986).

In closing we give a brief description of our evaluation plan.

3 Evaluation

We will evaluate the effects of the program all through its three-year duration. We will track the GEMS' choices with respect to college. This will allow us to make inferences about our high level goal, choosing a career in SEM, from the intermediate goal of choosing SEM in college.

3.1 Formative Evaluation

During the summer, Friday sessions will be devoted to sharing, categorizing, and codifying effective teaching tips for working with students in the target population. For example, with respect to self-confidence, the following would be noteworthy: The girls had been unwilling to ask questions when they were unsure. We therefore allowed them to pose questions as anonymous notes which we answered publicly. After a few sessions we noticed an increase in public question-asking.

Our work with the community will be assessed throughout each year. For example, with respect to climate change for grandparents: If we found that grandparents were more likely to encourage the girls when we included speakers of their generation (Sears, 1979, 1986), we would consider that in our balance of speakers over time.

3.2 Summative Evaluation

Pre- and post-summer, and pre- and post-project survey and interview data will be collected from students, family, school and community participants on each outcome below. The sample questions below

⁶These traditions represent the GEMS' historical cultures.

are adapted from a questionnaire developed by Professor Ann Parelius, Department of Sociology for the Douglass College Project for Rutgers Women in Math, Science and Engineering. Directly observed behavioral changes will also be noted.

Due to space limitations, we give one telling example of a behavioral indicator and/or a survey or interview question and/or an indirect measure for some key expected outcomes.

1. Increased belief that SEM is relevant to their lives.
 - Sample Likert scale question: People who enter math and science careers tend to be “nerds” who lack social skills.
2. Believe a SEM-related identity is compatible with an identity as a woman.
 - Behavioral indicator: Introduce their SEM and non-SEM friends.
 - Sample Likert scale question: Girls who are good in math or science are just as popular with boys as other girls are.
3. Take advantage of opportunities to participate in SEM activities.
 - Behavioral indicator: Engaging in challenging new activities.
 - Indirect measures: Number of new clubs, etc. joined.
4. Create a school, home and community climate conducive to choosing a life in SEM.
 - The examples above are for evaluating the girls; the analogous examples will provide insight into community change and will be pursued in equal depth.
5. Career awareness.
 - At the end of the three years we will evaluate the girls’ plans with respect to futures in SEM.

4 References

- Armstrong, J.M., and Kahl, S. Achievement and Participation of Women in Mathematics: An Overview Report of a Two-Year Study. Report no. 10-MA-00. Washington, D.C.: National Institute of Education, 1980.
- Bandura, A. (1977) Self-Efficacy: Toward a Unifying Theory of Behavioral Change. *Psychological Review* 84 (2), 191-215.
- Betz, N.E. (1994). "Women in the Sciences and Engineering". In W.B. Walsh and S.H. Osipow (eds.) *Career Counseling for Women*. (pp. 237-262) Hillsdale, NJ: Lawrence Erlbaum Association.
- Brown, L.M. and Gilligan, C. (1992) *Meeting at the Crossroads: Women, Psychology and Girls*. Development. Cambridge, MA: Harvard University Press.
- Chodorow, N. (1978) *The Reproduction of Mothering*. Berkeley, CA: University of California Press.
- Clewell, B., and Anderson B., 1991. "Women of Color in Mathematics, Science and Engineering." DC: Center for Women and Policy Studies. Washington, D.C.
- Clewell, B., Anderson B., and Thorpe, M.E. *Breaking the Barrier*. San Francisco: Jossey-Bass, 1992.
- Eccles, J. S. (1993) School and family effects on the ontogeny of children's interests, self-perceptions, and activity choices. In J. E. Jacobs (Ed.), *Nebraska Symposium on Motivation: Developmental Perspectives on Motivation* (Vol. 40, pp. 145-208). Lincoln, NE: University of Nebraska.
- Eccles, J.S. and Jacobs, J.E. (1986) "Social Forces Shape Math Attitudes and Performance Signs". *Journal of Women in Culture and Society*, 11(2), 367-380.
- Ethier, K. and Deaux, K. Hispanics in Ivy: Assessing gender identity and perceived threat. *Sex Roles*, 9, 943-52.
- Fitzpatrick, J.L. and Silverman, T. (1989). "Women's Selection of Careers in Engineering: Do Traditional - Nontraditional Differences Still Exist?" *Vocational Behavior*, 34, 266-278.
- Gagne, R.M. *The Conditions of Learning*. (3rd ed.) Troy, Mo.: Holt, Rinehart & Winston, 1977.
- Geary, D.C. (1994) *Children's mathematical development*. Washington, DC: APA.
- Hall, R.M. and Sandler, B.R. (1982). *The Classroom Climate: A Chilly One for Women? Project on the Status and Education of Women*. Washington, DC: Association of American Colleges.
- Hill, J.P. *Understanding Early Adolescence: A Framework*. Carrboro, N.C.: Center for Early Adolescence, Department of Maternal and Child Health, School of Public Health, 1980.
- Holmes, V.L. and Esses, L.M. (1988). "Factors Influencing Canadian High School Girls' Career Motivation". *Psychology of Women Quarterly*, 12, 313-328.
- Keller, Evelyn F. (1985) *Reflections on gender and science*. CT: Yale University Press.
- Kimball, M.M. (1992). *Women's Worlds: Men's Worlds: Exploring Gender Similarities and Differences*. Paper presented at the Canadian Psychological Association Meetings, Quebec City.
- MacCorquondale, P. "Self-Image Science and Math: Does the Image of the 'Scientist' Keep Girls and Minorities from Pursuing Science and Math?" Paper presented at the annual meeting of the American Sociological Association, San Antonio, Tex., Aug. 1984.
- Morgan, C.S. (1992). "College Students' Perceptions of Barriers to Women in Science and Engineering". *Youth and Society*, 24 (2), 228-236.
- Orenstein, P. (1994) *School Girls*. NYC: Doubleday.

Sadker, M. and Sadker, D. (1991). "Sexism in American Education: The Hidden Curriculum". In L.R. Wolfe (Ed.) *Women, Work and School*. (pp. 57-76). Boulder, Co.: Westview Press.

Sadker, M. and Sadker, D. (1994). *Failing at Fairness: How America's Schools Cheat Girls*. New York: Scribners.

Smith, W.S., and Erb, T.O. "Effect of Women Science Career Role Models on Early Adolescents' Attitudes Toward Scientists and Women in Science." *Journal of Research in Science Teaching*, 1986, 23(8), 667-676.