

Locus of Control and Mathematically Gifted Girls: Effects of Early Intervention

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It is commonly held that boys are better than girls at math. Research has shown that this difference is even more pronounced for mathematically gifted children. Mathematically gifted girls tend to devalue their ability. A program designed to bolster positive attitudes towards mathematics in fourth- and fifth-grade females is described. Fifteen girls were given the Intellectual Achievement Responsibility Questionnaire (IAR), participated in a week-long mathematics enrichment program, and were then retested with the IAR. Subjects demonstrated a statistically significant increase in their level of academic locus of control as measured by the IAR.

Introduction

Conventional folk wisdom holds that boys are better than girls at math. Decades of test scores seem to validate this assumption and, until recently, girls were steered away from academic programs involving a mathematics concentration. Although there are unsubstantiated studies to suggest the "gender gap" is narrowing (Begley, 1988; Viadero, 1991), entrenched beliefs such as the ones mentioned above have shaped social attitudes and practices in ways that are detrimental to girls—especially girls who are talented in math (Reis & Callahan, 1989).

Studies of mathematically precocious youth, like the ones by Julian Stanley at Johns Hopkins University, consistently demonstrate that gender differences in mathematical achievement appear to be greater among these students than among their less able peers. Gender differences in math achievement become increasingly evident and more pronounced in early adolescence (Benbow & Stanley, 1980; Eccles, 1985). This means that mathematically gifted females are at even greater risk of long-term underachievement than females with average mathematical ability.

Mathematically gifted females tend to devalue their mathematical ability, evidencing negative causal attributions for academic performance (Dweck, 1986; Dweck & Elliot, 1983). This self-defeating behavior compounds the

risk of lifelong underachievement for girls who are mathematically able. Many experts (Fox, 1980; Robinson, 1982; Stanley & Benbow, 1982) have suggested early intervention as a solution to this perplexing problem, theorizing that such intervention can increase feelings of efficacy and bolster positive attitudes toward mathematics instruction.

In spite of the strong recommendations from this body of research, there is a dearth of literature dealing with programs for mathematically gifted girls below the age of thirteen. This paper will describe an innovative residential math camp for mathematically gifted girls, aged 9-11, and will explore whether participants' scores on a measure of locus of control are affected as a result of their participation. In addition, this researcher will explore whether selected demographic variables, either singly or in combination, can be correlated with participants' pre- and post-test measures of academic locus of control.

Female-aticians

The Female-aticians Program at St. Francis College in Fort Wayne, Indiana, was begun in the summer of 1988 to identify and serve young mathematically gifted females in the hope that their program participation would lead to (a) increased awareness of potential, (b) improved academic/mathematic self-perception, and (c) guidance in career planning. A week-long residential academy, Female-aticians offers qualified students a chance to study mathematics in-depth through such specially designed courses as Binary

Math, Geometry, Calculator Math, Orienteering, Scientific Problem Solving, Math Mysteries and Paradoxes, Music and Math, and Creative Problem Solving. In addition, participants interact academically and socially with other mathematically gifted girls and the mathematically able female instructors who design the courses and serve as positive role models. Instructors for the program are hand-selected by the Program Director (a female school administrator with a doctorate in education), who guides their course development to ensure that course offerings reflect experiences extending beyond the basic computational exercises and disguised drill and practice which often pass for "enrichment" in mathematics textbooks.

In the early years of the Female-aticians program, no objective measures were used to determine program effectiveness. This study was an attempt to measure changes in locus of control by an outside researcher through pre- and post-test administration of the Intellectual Achievement Responsibility Questionnaire - Short Form, Revised (Crandall, 1978), and to search for possible correlates of predicted female academic success in mathematics through completion of a Personal History Questionnaire. It was hypothesized that participants in the Female-aticians Program would evidence a positive gain on measures of academic locus of control.

Method

Fifteen girls who had completed fourth or fifth grade; who had scored at or above the 96th percentile on the state standardized achievement test in mathematics; who had been nominated by teachers, administrators, and/or parents; and who had passed through the application screening procedure were the identified participants. (The screening procedure consisted of a completed application form submitted to the Program Director prior to a publicized deadline. This application form served to document verbal nominations to the program, and included a written rationale for each girl's nomination.) Prior to beginning the residen-

tial program, all 15 participants completed the short form of the Intellectual Achievement Responsibility Questionnaire (IAR). Participants also completed a Personal History Questionnaire requesting such demographic information as parents' occupations and educational levels, participants' birth order, hobbies and extracurricular activities, and career plans. All 15 girls subsequently participated in a week-long residential mathematics enrichment program at St. Francis College, after which they again completed the IAR.

Data Source

The Intellectual Achievement Responsibility Questionnaire (Short Form, Revised) is a children's scale composed of 14 forced-choice items (7 rated "positive reinforcers," and 7 rated "negative reinforcers"), aimed at assessing children's beliefs in reinforcement responsibility for exclusively intellectual-academic situations. Sources of external control measured are limited to persons who most often have direct contact with children: parents, teachers, and peers; and the examples used in both positive and negative reinforcer statements are patterned after common school experiences (example: "When you remember something you heard in class, is it usually (a) because you tried hard to remember, or (b) because the teacher explained it well?").

Items on the IAR are subdivided into positive and negative reinforcers. Reliability has been established at the elementary level for the total score as well as each of the two subscales (.69 for the total scale score (I), .66 for the positive (I+) subscale, and .74 for the negative (I-) subscale). Measures of internal consistency are .54 for positive items, and .57 for negative items.

Results

Individual and group scores were obtained for total scale, positive subscale, and negative subscale items on both pre- and post-test administrations of the IAR through simple frequency counts. Mean pre-test scores were similar to the scores of non-gifted females from other IAR studies (Crandall, personal communication, 1990). Post-test analyses of both

Table 1
IAR Group Scores for 15 Mathematically Gifted Girls Participating in the Female-aticians Program

	Pre-Test Means	Post-Test Means	Gain
I+ ¹	6.27	6.47	.20
I- ²	5.07	5.47	.40
Total I	11.34	11.94	.60

¹ Positive Reinforcer Statements

² Negative Reinforcer Statements

Table 2
Categories of Career Goals Among Female-aticians Participants

<u>Category*</u>	<u>Frequency</u>	<u>Percentage</u>
Artistic/Investigative	1	7
Artistics/Social	2	13
Enterprising/Social	1	7
Investigative/Enterprising	1	7
Investigative/Realistic	5	33
Social/Artistic	2	13
Social/Investigative	1	7
<u>Combined Categories</u>		
Investigative	10	67
Social	8	53
Artistics	5	33
Enterprising	2	13
Realistics	5	33

* Categories are adapted from Fox, L (1973), Values and career interests of mathematically precocious youth: ERIC Documents, and determined for Female-aticians participants through descriptive analysis and simple frequency counts.

Table 3
Analysis of Personal Hobbies Indicated by Female-aticians Participants' Self-Reports

<u>Category*</u>	<u>Frequency</u>	<u>Percentage</u>
Reading	7	47
Playing Piano	5	33
Drawing/Art	5	13
Writing	2	13
Singing in Choir	1	7
Cooking	1	7
Watching Television	1	7
Playing Video Games	1	7
Playing Basketball	3	20
Skating	3	20
Skiing	1	7
Playing Volleyball	1	7
Gymnastics	2	13
Biking	4	27
Playing Kickbakk	1	7
Horseback Riding	1	7
Playing Outdoors	1	7
Ballet Dancing	1	7
Collecting	10	67
<u>Combined Categories</u>		
Collecting	10	67
Active Sports	11	73
Reading	7	47

total scale and subscale scores revealed some significant differences. As a group, the subjects showed statistically significant gain in measures of academic locus of control following participation in the residential math camp (.60 total scale score). The girls in this study, however, were more likely to accept responsibility for academic failure than for academic success.

Correlation analyses of birth order, family size, parental education, or parental occupational levels to changes in measures of locus of control were largely inconclusive. These analyses are of note because past studies (Fox, 1973) have suggested that birth order, parental career status, parents' education, and/or socioeconomic levels are positively correlated with girls' math performance. Two items of interest from subjects' Personal History Questionnaires, however, show potential for future research of this type: the apparent connection between hobbies and career aspirations of young girls and their tendency toward mathematical giftedness (see Tables 2 and 3).

Discussion

The body of research on mathematically gifted females yields two conclusions relevant to this study: (a) the gender gap for mathematics achievement is even greater between mathematically gifted girls and mathematically gifted boys than between girls and boys who are not mathematically gifted, and (b) mathematically gifted girls tend to exhibit lower scores on measures of academic locus of control than mathematically gifted boys. Originators of the IAR (Crandall, Katkovsky, & Crandall, 1965) insist that "it seems probable that a belief in self-responsibility constitutes a motivational influence upon achievement performance. . .". Children who feel responsible for their own successes and failures "should show greater initiative in seeking rewards and greater persistence in the face of difficulty" (p. 108). If educators can find ways to increase gifted girls' feelings that they have some control over their mathematical achievement, we may be able to decrease the probability of lifelong underachievement. The Female-aticians Program demonstrates that effective strategies do exist—strategies which can positively affect young mathematically gifted girls' locus of control. Using both affective and academic strategies in a residential setting, instructors in this program designed an experience that immersed young mathematically gifted females in math theory and practice, through classes and social events that placed them in the company of like-ability peers.

In short, even though this was a preliminary study with a small sample size and no control group, the results pose interesting considerations for future research of this kind. The fact that young mathematically gifted girls entered an enrichment program with a mean total scale IAR score equivalent to that of their nongifted female peers (see Crandall, 1978), and after completing the week-long residential mathematics program scored significantly (.60%) higher on a

measure of academic locus of control, tells us it is possible that early positive intervention efforts can have a positive effect on mathematically gifted females' development.

This researcher recommends early identification for gifted girls, and early positive intervention in the form of challenging curriculum—consistent and thoughtful intervention that meets the intellectual demands of young gifted minds on a regular basis. This recommendation is not new, but many schools and communities have yet to act on it. Enrichment programs for the gifted take place sporadically, if at all, and both enrichment programs and Advanced Placement courses usually begin toward the end of a youngster's formal schooling. If educators are to take responsibility for changing the patterns of the past that have proved detrimental to gifted girls, we must begin earlier.

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