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ABSTRACT

In week-long semesters in the summers of 1997, 1998, and 1999, the 6APT (Summer Institute in Computer Science for Advanced Placement Teachers) project taught 240 high school teachers of Advanced Placement Computer Science (APCS) about gender equity in computers. Teachers were then followed through 2000. Results indicated that while teachers, did in fact increase the number of equity strategies they carried out, there was no corresponding increase in girls' enrollment in APCS courses. Speculations about the results are offered. Three major conclusions were drawn: (1) there was an increase after the 6APT experience in the percentage of computer teachers carrying out equity strategies and an increase in the number of strategies they carried out; (2) while there were changes in the numbers of students enrolled, both male and female, they were likely attributable to the change from Pascal to C++ programming language in May 1999 and not the 6APT training; and (3) the number of recruitment and retention strategies used by teachers whose female enrollment did not increase or change remained at 2.0, while those teachers who were most successful in increasing female enrollment increased the strategies they used from a mean of 1.0 to 1.5, and the number and type of strategies did not appear to be related to changes in enrollment. (Contains 32 references.) (Author/AEF)

Snatching Defeat from the Jaws of Victory: When Good Projects Go Bad

Girls and Computer Science

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Snatching Defeat from the Jaws of Victory: When Good Projects Go Bad [1]

Girls and Computer Science

Abstract. In week-long seminars in the summers of 1997, 1998, and 1999, the 6APT (Summer Institute in Computer Science for Advanced Placement Teachers) project taught 240 high school teachers of Advanced Placement Computer Science (APCS) about gender equity in computers. Teachers were then followed through 2000. Results indicated that while teachers did in fact increase the number of equity strategies they carried out, there was no corresponding increase in girls' enrollment in APCS courses. Speculations about the results are offered.

Integrating gender equity training and teacher retooling for the high school Computer Science classroom, titled informally as the 6-APT project: Summer Institute in Computer Science for Advanced Placement Teachers. Awarded to Carnegie Mellon University, Allan Fisher, P.I., 1997-2000 (extension through 2001); sub-award to Washington Research Institute, co-P.I. Jo Sanders. National Science Foundation grant no. HRD-9618865.

Taking advantage of the opportunity that the programming language of the AP exam in Computer Science was due to change from Pascal to C++ in May 1999, we held two seminars every summer at Carnegie Mellon for 40 APCS high school teachers at a time, for a total of 240 teachers over three years, almost one-quarter of all APCS teachers in the U.S.

Half the time at the week-long seminar was spent learning C++, while the other half was spent learning gender equity in computing in a variety of gender equity sessions. After the seminar, teachers were networked by means of a listserv. We held two follow-up conferences.

We found that although teachers did increase their equity activities with students, female enrollment changes overall were disappointing. This may have been due to insufficient follow-up by project staff, ineffective gender equity efforts by teachers, or other reasons.

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BACKGROUND

Girls in Computer Science

With the exception of physics, Computer Science (CS) is now the only technical subject in which boys substantially outnumber girls at the high school level (National Center for Education Statistics, 2000).

In 1998, girls earned 0.71 Carnegie Units in Computer Science courses while boys earned 0.78 Units (op. cit.). However, the only nationally comparable measure we have of any specific computer courses at the secondary level is the Advanced Placement (AP) program. In 2001, there were lower percentages of female test-takers in the two CS exams than in any of the other 19 AP exams: 17% for the one-semester "A" exam, and 9% for the two-semester "AB" exam. An average of only 16 girls per state took the more advanced exam. (Education Testing Service, Advanced Placement 2001 National Summary Report)

In post-secondary Computer Science degrees, we also see more women at lower levels and fewer at the upper levels. In 1997, women earned 48.2% of the Associates degrees, 27.1% of the Bachelors, 28.2% of the Masters, and 15.9% of the Doctorates. (National Center for Education Statistics, 2000). This is a decrease for women in both number and proportion since 1984, when they earned 37% of the bachelor's degrees in CS.

And not surprisingly, we see imbalances as well in the work force...In 2000, women were 46.5% of the total workforce but 29.2% of computer systems analysts and scientists, 26.5% of computer programmers, and 9.8% of electrical and electronic engineers (Bureau of Labor Statistics, 2001, Table 11).

These trends show no sign of changing any time soon. A recent survey of high school girls about their career plans showed Computer Science tied for last place — 11th — at 2 percent, with architecture and politics. (McClain, 2001)

These numbers reflect a country in which relatively few women obtain the qualifications to create — as opposed to use — our technology. As a recent New York Times editorial said, "Studies show that women are active users of the new technology and that female Internet users slightly outnumber male users. But the paucity of women creating that technology is cause for concern." (New York Times, 2000) As Frenkel (1990) stated, "One wonders how many ideas that could have been contributed by female talent will never surface to enrich academic computer science. More broadly, what are the repercussions to our increasingly computer-oriented society if women — about half the population and professional work force — are not as prepared in this discipline as are men?"

The Importance of Computer Experience for Girls

Research on the importance of prior computer experience for girls' continuation in postsecondary CS is now substantial (AAUW Educational Foundation, 2000; Bunderson & Christensen, 1995); Carver, 2000; Dryburgh, 2000); Koohang & Byrd, 1987; Martin & Wardle, 1999; Miura, 1987; Shashaaani, 1997; Taylor & Mounfield (1994); Wilder, Mackie & Cooper, 1985).

"Prior computer experience is associated with greater success in computer education at the postsecondary level, [but] [a]ll studies indicate that women are less prepared than men entering CS" (Dryburgh, 2000, p. 193). Carver (2000) reports on a study carried out at SUNY Genesco, in which she identified women's lack of prior computer experience as a significant barrier to persistence. Taylor and Mounfield (1994) surveyed college students in an introductory computer science course for non-CS majors about their prior computing experience. While programming alone was significant in the successful course completion rate for males, any secondary CS courses were significant for females. The difference in the success rate for males between those who had not had high school CS courses and those who had was 8%, but the difference for women was 30%. Taylor and Mounfield conclude that their "study clearly indicates that high school computer science has the potential to help females succeed in college courses and can play a major role in success in college computer science" (p. 298).

Shashaani (1997) and Taylor & Mounfield (1994) identified prior experience with home computers and personal computer ownership critical elements for females continuation in CS. Shashaani (1997) reports that male college students in her sample were likelier to own a home computer. Students were much likelier to say that the primary home computer users were male (70%, compared to 25% for female primary users). Taylor & Mounfield (1994) found that the female college students most likely to do well in an introductory CS course were those who owned their own computer. Prior computer experience for girls is also associated with positive attitude towards computers (Dryburgh, 2000) and with interest in computers (Shashaani, 1997).

Programming is apparently a major source of the gender gap in computing. Fewer girls take programming in high school than boys, and programming is identified as an equity barrier (Bunderson & Christensen, 1995; AAUW Educational Foundation, 2000). Contrary to Taylor & Mounfield's results that found earlier programming experience significant for boys only, Miura (1987) found programming to be the best predictor of self-efficacy in computing for females. Wilder, Mackie & Cooper (1985) reported that "only learning a programming language increased females' sense of computer competence (p. 226)." Further new research is needed to clarify the role of programming for girls.

It appears that success in CS at the college level for females is heavily reliant upon previous computer experience in high school (Shashaani, 1997) and probably upon previous programming experience. Given the gender gaps in computer course-taking at the high school level, this trend is cause for concern.

Computer Equity Strategies

There is a substantial literature on strategies that have been tried and reported as successful to encourage girls' persistence and success in CS (e.g., Burger & Sandy, 1999; Burger & Sandy, 1998). This research builds on similar accomplishments in the past twenty years in mathematics and science, and computer science is beginning to echo the same themes (Martin & Wardle, 1999). We no longer have to worry about one issue, at least: "access" to computers, in the sense of insufficient equipment, is no longer a gender barrier. While in 1983 there were 125 students per computer, the ratio in 1998 was 1:6. Internet access is also better: 54% of schools were connected in 1994 and 90% in 1997 (Yau, 1999).

Several researchers have proposed classification systems of factors that account for achievement and persistence in technical areas. Farmer (cited in Paa & McWhirter, 2000) formulates that career and achievement motivation arise from background, personal, and environmental variables. It is the environmental variables — encouragement from significant others, role models, etc. — that are most open to influence in the form of equity strategies. Reynolds & Walberg (cited in Wang & Staver, 2001) group factors that influence student achievement into a different set of three categories: student aptitudes, instruction quantity and quality, and social-psychological environment. The latter category includes educational, home, peers, and media. Here, instruction and environment are the categories that are most open to influence.

In this project, I am proposing to emphasize only those factors that are open to influence — in other words, susceptible of being manipulated as gender equity strategies. To streamline analysis, I propose to have schools implement specific strategies in four clusters that seem to be the most salient in the literature: 1) Parent strategies. 2) Curriculum strategies. 3) Classroom dynamics strategies. 4) Career exploration strategies.

Parent strategies. Several studies report that parental influence in favor of technical education and careers is highly influential for girls (Paa & McWhirter, 2000; Manitoba Department of Education and Training, 2000; Shashaani, 1997; Burger & Sandy, 1999). In a study of undergraduates enrolled in an introductory CS course, Shashaani (1997) found that female students who perceived that their parents considered computers more appropriate for males were less interested in computers for themselves. They also had lower confidence in their computer ability than other female students. The same author, in an earlier study about parents' gender biases and daughters' computer behavior, found that both male and female high school students reported sex-stereotyped parental attitudes about computers. Boys were more likely to report parental encouragement, and that sex-typed views — maternal and paternal — negatively affected girls and positively affected boys (Shashaani, 1994).

Curriculum strategies. Traditional computer science curriculum has been found problematic for girls in its narrowness and boredom (Dryburgh, 2000). Clarke & Teague (1996) found that high school girls and postsecondary female CS majors both had sex-stereotyped views of computer science. Ironically, the very factors these groups said would be attractive to them in careers were the factors adult women CS professionals cited as why they loved their jobs. Clarke & Teague concluded that CS curriculum is unnecessarily restrictive, irrelevant, and lacking in direct applications. CS curriculum gives students the idea that CS is not people-oriented (Bunderson & Christensen, 1995; Honey et al., 1991). Of particular interest to me, at least, are those who say that promoting play and tinkering would help to increase girls' interest in CS (Smith, 2000; Jones et al., 2000; and Burger & Sandy, 1999).

Classroom dynamics strategies. For many years, classroom dynamics have been said to be an equity barrier. The need to eliminate gender-biased classroom interactions between teacher and students has been addressed in many publications (Sadker & Sadker, 1994; Bailey et al., 1992; Grossman & Grossman, 1994, among many others). Burger & Sandy (1999) and Smith (2000) contend that the opportunity to socialize and share in the context of computer activities increases interest for girls. Jones (2000), Smith (2000), and Oberman (2000) discuss the advantages and pitfalls for girls of collaborative/ cooperative learning.

Career exploration strategies. Nearly every published source on closing the high school computer gender gap recommends career strategies. Adult women in CS stressed the importance of informing girls that CS careers involved helping people (Smith, 2000; Clarke & Teague, 1996). Girls were found to consider career counseling more important than boys did (Manitoba Department of Education and Training, (2000). Many authors cite the importance of role models (Miura, 1987; Paa & McWhirter, 2000; Bunderson & Christensen, 1995; Dryburgh, 2000), while researchers from Scotland caution that they found no role model effect for female teachers (Roger & Duffield, 2000). (This may be caused by the fact that, as I have observed, there are not two sexes but three: male, female, and teacher!) Farmer (cited in Madill et al., 2000, p. 18) points out that career messages vary. Young women are told "Do what you want and be happy," while the message for young men is "Get good grades so you can get into the best schools and be successful in a career," causing different responses by sex.

In addition to the typical computer scientists, Maria Klawe says, "we need more computer scientists whose passions are art, language, literature, education, entertainment, psychology, biology, music, history, or political science. We need them because computers have an impact on all areas in our world." (Klawe, 2001) We are far from achieving this goal.

- **The 6APT Project**

Allan Fisher at Carnegie Mellon University (CMU) and Jo Sanders at Washington Research Institute developed 6APT to increase the number of women in computer science by means of encouraging teachers to better recruit and retain girls in advanced placement computer science (APCS) courses. To do this, we conducted weeklong seminars in the summers of 1997, 1998, and 1999 for 240 high school teachers of APCS courses, at 40 teachers per seminar. Half the week was spent teaching them C++, and the other half of the week was spent teaching them gender equity: background, relevance to computer science, and especially, equity strategies for counteracting girls' computer avoidance.

Recruitment for computer teachers was efficiently conducted by means of the APCS electronic list, which resulted each year in more applications than we had space for. Applications and additional baseline data were read and selected by CMU project staff.

The major gender equity sessions and instructors at each seminar for 40 computer teachers were:

- Gender equity: setting the stage (Jo Sanders)
- Debriefing from participants' prior mini-assignments concerning gender equity in education and society (Sanders)
- Why girls choose CS, and why they don't (Allan Fisher)
- Attribution theory and stereotype threat (Sanders)
- Findings from CMU's earlier project on gender equity and computing (Jane Margolis)
- How to improve recruitment (Sanders)
- Classroom climate: intro, Dateline video, role play (Sanders and Fisher)
- Feminist pedagogy (Sanders), enriching programming problems (Fisher)
- Overcoming common barriers (Sanders)
- Computer equity in schools: teams and the acceptance continuum (Sanders)
- Planning: first action, one year, and long term (Sanders)

Follow-up was conducted via a listserv and two optional conferences. Each participant was sent a follow-up questionnaire in the fall one year after his or her seminar. Upon return of the completed questionnaire we sent them a stipend of $200. We sent three annual follow-up questionnaires to the '97 seminar cohort (1998, 1999, 2000), two to the '98 cohort (1999, 2000), and one to the '99 cohort (2000).

METHOD

We realized that knowing about changes in teacher behavior was necessary, but it was not sufficient. We also needed information on the results of their behavior in terms of APCS course enrollment and to find out if there were any correlations between changes in teacher behavior and changes in enrollment. As part of the project evaluation, 6APT collected preliminary and annual follow up information, including male and female student enrollment in APCS, from the three participants cohorts. However, data collection and response rate problems plagued us throughout the project. In the fall of 2000, we asked Campbell-Kibler Associates to contact a sample of nonresponding participants from the 1997 and 1998 cohorts in order to collect current information and code, enter and analyze the data from the 1997 and 1998 cohorts. Data from the 1999 cohort was collected in the fall of 2000.

The telephone interview questions we agreed upon were:

1. What is your current enrollment in your advanced placement computer science courses (broken out by race/ethnicity and sex, if possible)?
2. Have you undertaken any special efforts to recruit and/or retain female students in computing courses? If yes, could you describe what you did? What was the result? When did you begin doing that?
3. Has the 6APT experience led you to make any changes in your teaching and other interactions with students? If yes, could you describe the changes? When did you begin each change?
4. What computer related extra curricular activities do students in your school participate? For each, describe and estimate the numbers of males and females who participate.

Teachers in the 1997 Cohort (Cohort 97)

Fourteen of the 79 Cohort 97 teachers had responded to CM/WRI requests for information on the 1999-00 school year. Preliminary data and data from either the 1997-98 or 1998-99 school years were available from 26 of the remaining 65 teachers who had attended the 1997 training but did not respond to repeated requests for 1999-00 data. It was decided to focus on these 26 teachers for whom there were at least two data points. Teacher activity data was received from 17 of the 26 teachers and APCS enrollment data was received from 16 teachers. Three of the 26 teachers no longer teach APCS, two are no longer teaching, two had incorrect numbers and two chose not to respond. Thus 1999-00 data was received from a total of 31 teachers who attended seminars in 1997, 30 of whom had enrollment data.

Teachers in the 1998 Cohort (Cohort 98)

Seventeen of the 80 Cohort 98 teachers had responded to CM/WRI requests for information on the 1999-00 school year. Preliminary data and data from the 1998-99 school year were available from 26 of the remaining 63 teachers who had attended the 1998 training but did not respond to repeated requests for 1999-00 data. It was decided to focus on these 26 teachers for whom there were at least two data points. Teacher activity data was received from 12 of the 26 teachers and APCS enrollment data was received from eight teachers. Eight of the 26 teachers no longer teach APCS, and six chose not to respond. Thus 1999-00 data was available from 29 teachers who attended seminars in 1998, 25 of whom had enrollment data.

Teachers for whom there were at least two data points prior to the 1999-00 data collection were targeted for follow up in order to maximize the possibility of doing an analysis of trends and relating strategies carried out after participating in 6APT to enrollment changes. Because students' enrollment decisions for the following year were made in the spring before teachers participated in 6APT, year 1 enrollment data would not reflect the results of any changes in teacher recruitment or teaching strategies. Year 2 data would be first year in which teacher changes could have an impact on enrollment. Thus the 1999-00 school year data from teachers from the 1999 Cohort would not show any 6APT impact, so follow up for this analysis was not done for the 1999 Cohort.

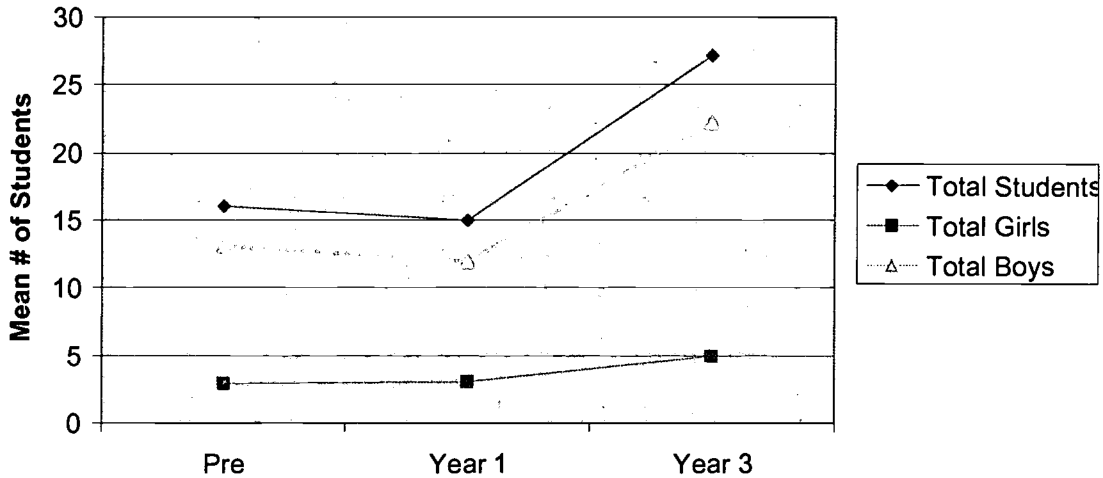
RESULTS

Student Enrollment

No major changes in APCS enrollment were expected between the preliminary and year 1 data because students had already registered for their APCS course before teachers attended 6APT. 6APT could have contributed to changes in enrollment between year 1 and year 3[2]. As Chart I indicates, as expected the APCS enrollment data for year 1 (1997-98) for Cohort 97 was very similar to that of the year before (1996-97). There was a strong increase in overall APCS enrollment between year 1 (1997-98) and year 3 (1999-00), although there was minimal change in the number of girls enrolled.

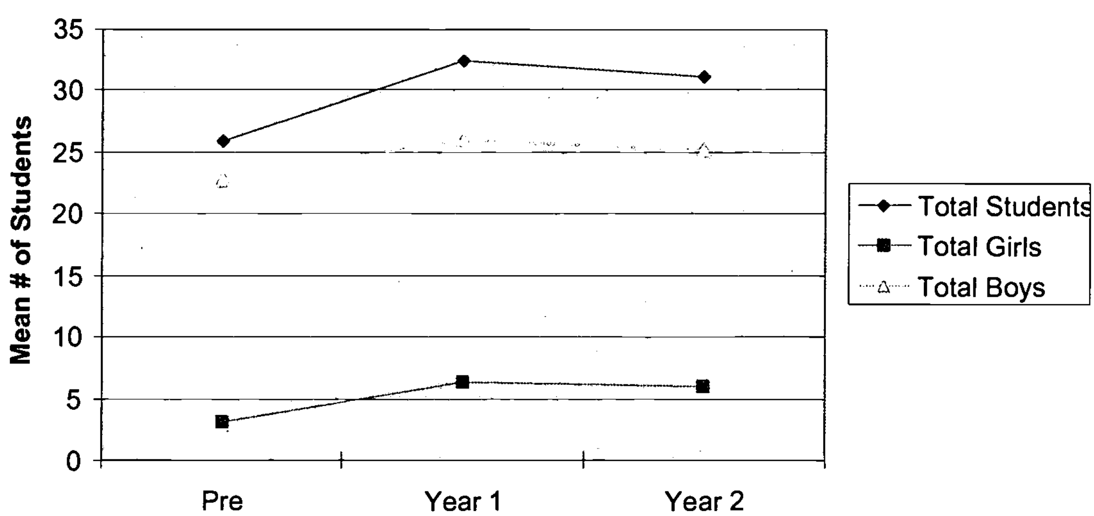
[2] So little comparison data was available for year 2 (5 cases) that it was not included.

Chart I: Changes In Student AP CS Enrollment Cohort 97(N=2



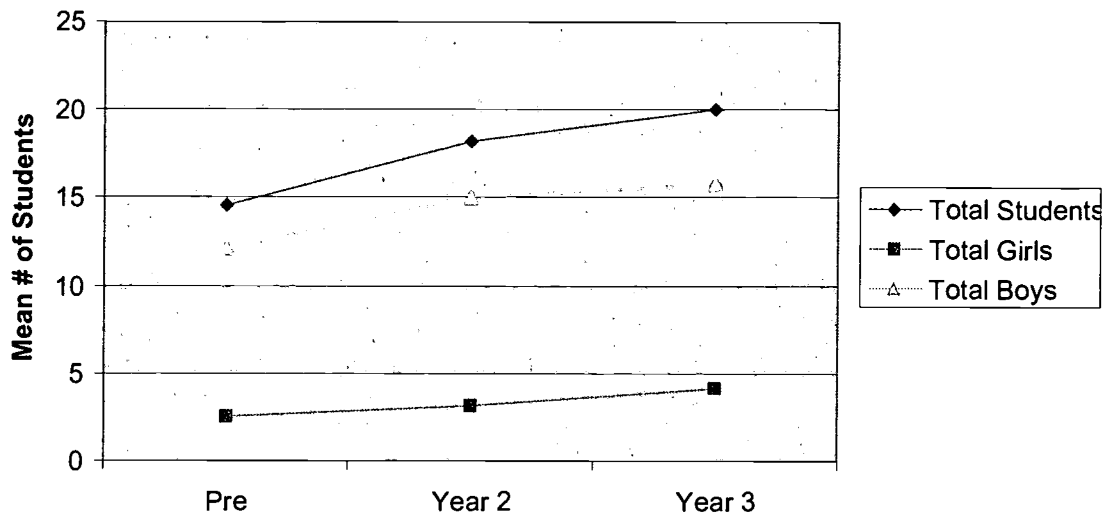
The pattern was different for the Cohort 98. As Chart II shows, the APCS enrollment went up between the preliminary year (1997-98) and year 1 (1998-99), an increase that cannot be attributed to 6APT since students had already registered for the course before their teachers' participation in 6APT. Between year 1 (1998-99) and year 2 (1999-00) when enrollment changes could have been attributed to 6APT, enrollment changes were minimal. As with Cohort 97, the changes in girls' enrollment were minimal.

Chart II: Changes In Student AP CS Enrollment Cohort 98 (N=2



The biggest increase in enrollment came for Cohort 98 during year 1, the 1998-99 school year. This was the year that C++ replaced Pascal in most high schools as the APCS language. While there is only data for 11 of the Cohort 97 teachers that includes the year 2/1998-99 school year when C++ replaced Pascal, Chart III appears to indicate that the major increase in Cohort 97 enrollment occurred during the switch from Pascal to C++.

Chart III: Changes In Student AP CS Enrollment: Cohort 97 (N=11



Equity Strategies

To assess the possible impact of teachers' equity strategies intended to increase girls' recruitment and retention in APCS, comparisons were made between the 11 Cohort 97 teachers who increased their overall student enrollment by at least 80% after participating in the project and the 12 Cohort 97 teachers whose overall enrollment either remained the same or decreased.

In Table I, we examined the number of equity strategies used by teachers in relation to their total male and female enrollment changes. Those teachers whose enrollment did not increase or change remained at 2 strategies [3], while teachers who were most successful in increasing the total enrollment increased the strategies they used from a mean of 1.0 to 1.5. By Year 3, teachers with no enrollment changes were more apt to involve others in recruitment (6 vs. 3) and

[3] One teacher whose enrollment did not change, reported increasing the number of recruitment retentions strategies she did from 3 to 11, somewhat skewing the data. Her data was not included in the means.

use written materials (4 vs. 0). However, teachers with enrollment increases were likelier to go to classes, (including their own) to recruit students than were teachers with no changes (4 vs. 0).

Table I: Changes in Equity Strategies Among Teachers with Large Changes and No Change in *Student* Enrollment Cohort 97. N: Large Change =11, No Change = 12

	Mean # of students enrolled	Mean # of girls enrolled	Mean # of equity strategies used
Large change, pre	13.9	2.7	1.0
Large change, Year 3	35.4	7.4	1.5
No change, pre	16.0	3.0	1.9
No change, Year 3	13.8	1.8	2.0

Similarly, Table II shows the number of equity strategies used by teachers in relation to their *female* enrollment changes. Comparisons were made between the nine Cohort 97 teachers whose female enrollment increased by at least four girls and the 10 teachers whose female enrollment either decreased to or remained at 0 or 1. The number of equity strategies used by teachers with either 0 or 1 girl in their classes increased from 1.6 to 1.9, while teachers who attracted at least four more girls after their involvement in the project increased the number of strategies they reported using from 1.1 to 2.

Table II: Changes in Equity Strategies Among Teachers with Large Changes and No Change in *Female* Enrollment Cohort 97. N: Large Change =9, No Change = 10

	Mean # of students enrolled	Mean # of girls enrolled	Mean # of equity strategies used
Large change, pre	18.1	2.7	1.1
Large change, Year 3	40.4	10.3	2.0
No change, pre	11.7	1.8	1.6
No change, Year 3	13.0	0.5	1.9

In Cohort 98, only two teachers increased their total APCS enrollment by at least 80%, and only three teachers increased their female enrollment by at least four girls. Because of the small numbers of teachers with strong enrollment increases in Cohort 98, no comparisons could be made.

However, after their 6APT experience, the number of teachers who reported carrying out equity strategies to recruit and/or retain girls increased from 64% to 92%, and the mean number of strategies each teacher carried out also increased, from 0.9 to 2.6. [Pat, this paragraph came from the very first paragraph of your report and doesn't seem to be connected to anything there. But there are no backup data for it here either, particularly the percentage change, and yet it is important. Can you help?]

Changes in Teacher Behaviors

For the first year after their participation in 6APT and in each additional year, teachers were asked about changes in their teaching behavior and other interactions with students. The 11 Cohort 97 teachers with Year 1 and Year 3 data and large *total* enrollment changes reported a mean of 2.5 changes in their teaching behavior in Year 1 and 2.0 in Year 3. This was similar to the eight teachers with none or negative enrollment changes, who reported 2.3 changes in behavior in Year 1 and 2.0 in Year 3. In Year 1, five of the "large enrollment change" teachers and one "no enrollment change" teacher reported changing their behavior to treat students more equitably, such as wait time, calling on all students and not allowing aggressive students to dominate.

Not surprisingly, this was also the case with teachers with large and no enrollment changes for *girls*. In Year 1, four of the "large-change" teachers and one "no- change" teacher reported changing their behavior to involve students more equitably. In Year 1, no teacher from the "large-change" group and four teachers from the "no-change" group reported talking to individual girls about taking APCS courses. Overall, teachers with an increase of 4 or more girls in their classes reported a mean of about 2 changes in Year 1 and again in year 3 (at 2.0 followed by 2.1), while teachers whose female enrollment remained at or decreased to 0 or 1 girl reported fewer changes in their behavior, from 2.3 in Year 1 to 1.3 in Year 3.

CONCLUSIONS

We drew three major conclusions.

1. There was an increase after the 6APT experience in the percentage of computer teachers carrying out equity strategies and an increase in the number of strategies they carried out.

2. While there were changes in the numbers of students enrolled, both male and female, they were likely attributable to the change from Pascal to C++ and not the 6APT training.

3. The number of recruitment and retention strategies used by teachers whose female enrollment did not increase or change remained at 2.0, while those teachers who were must successful in increasing female enrollment increased the strategies they used from a mean of 1.0 to 1.5. The number and type of strategies did not appear to be related to changes in enrollment.

Choosing to limit assessment of impact in this project to the computer teachers' gender equity behavior is based on an assumption of subsequent positive impact on girls. This is often logistically and financially necessary because measuring subsequent impact on girls can require more time and money than is available to most grant-funded projects. My previous projects all stopped at the direct-impact-on-participants level, and all, using this measure, were evaluated as being successful. I therefore had ample reason to think that if we could demonstrate positive impact on teachers, the project would be a success. And because we did show positive impact on teachers, I would have chalked up the 6APT project as one more "win."

In this project, however, we decided to go beyond teacher behavior and "confirm" our assumption that positive impact on teachers led to positive impact on girls — in other words, if teachers increase the number of equity activities they carry out, more girls will respond by enrolling in the Advanced Placement computer science course. We were sobered to discover that the former, which happened, did not lead to the latter, which did not.

The data do not provide reasons for this lack of impact, leaving us to speculate on possible areas for future exploration including:

- Reconsidering the approach of targeting lone computer teachers in a school
- Examining the impact of teacher follow-up done by 6APT project staff
- Examining the quality of the equity activities carried out, along with the specific number and type of strategies
- Taking an in-depth look at equity strategies used by teachers who consistently attract and retain large numbers of female students in APCS.

Our experience leads us to caution researchers about the use of interim proxy measures (in this case, change in teacher behavior) for desired ultimate behavior changes (in this case, increased female APCS enrollment). While interim proxy measures are often necessary due to expense or time limitations, it would be wise to give more thought to obtaining additional funds and/or time to be able to test the ultimate outcome directly.

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