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ABSTRACT

This paper explores alternative explanations for the persistence of difference between girls and boys in their attitudes toward technology and science. Reference is made to data from a project designed to introduce students in a science course to multimedia technology in a manner that would be conducive to encouraging girls as well as boys to become competent and interested, and therefore willing to pursue further opportunities. The project was launched in a suburban high school in the Pacific Northwest, and involved a project-based, cooperative, student-centered biology course. Pre- and post-tests measured student attitudes toward computers and science, prior experience with computers, and students' sense of efficacy in learning the new technology. They also completed the Bem Scale of Masculinity/Femininity. It was discovered that this careful construction of a learning environment still left differences in attitudes between the sexes, raising the question about the meaning of these differences and the efficacy of proposals to attain equality based on possibly incomplete explanations. A model for participation that emphasizes the importance of individual interests and perceptions of abilities is proposed. Data is presented in four tables and one figure. One figure illustrates the model for the relationship between variables predicting continued participation in science and technology. (Contains 49 references.) (Author/MAS)

The Baldwin Effect: A Basis for Sex Differences in Attitudes toward Technology and Science

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Abstract: This paper explores alternative explanations for the persistence of difference between girls and boys in their attitudes toward technology and science. Reference is made to data from a project designed to introduce students in a science course to multimedia technology in a manner that would be conducive to encouraging girls as well as boys to become competent and interested and therefore willing to pursue further opportunities. This careful construction of a learning environment still left differences in attitudes between the sexes, raising the question about the meaning of these differences and the efficacy of proposals to attain equality based on possibly incomplete explanations. A model for participation that emphasizes the importance of individual interests and perceptions of abilities is proposed.

Introduction: It appears that despite conscientious attempts to equalize opportunities and outcomes, sex differences persist in attainment of careers in the related fields of mathematics, science and technology (Meece & Eccles, 1993; Sutton, 1991; Shashaani, 1993). Much concern has been expressed within each field about the impact of differential participation for fulfillment of individual potential and of societal needs, and much effort has been made to change the patterns of attitudes and behaviors that lead to unequal outcomes (Kahle & Meece, 1994; Fennema, 1990). What is significant is that substantial gains have been achieved in providing equal opportunities and reducing bias, and yet the resultant inequalities of attainment persist. This suggests that the causal relationships being used to explain the results may not be adequate (Brush, 1980). If educational institutions are to contribute to the attainment of equality for men and women, they must attend to those factors that impact the interest and involvement of girls. Right now as computer and multimedia technology becomes a major mode of information access and processing, problem solving, and communication, it may be particularly important to examine explanations for differential participation in this area in an attempt to ensure that women are not unfairly limited in their opportunities (Burstyn, 1993).

The differences in achievement for men and women in these three areas have been linked to similar causes (Eccles et al., 1985; Kahle et al., 1993; Chen, 1986; Burstyn, 1993). Most explanations look to the environment for biases that lead to differential expectations and opportunities for the two sexes. The consequences for women of fewer experiences and less support are attitudes towards the subjects and towards their own abilities that do not encourage the continued commitment required for career attainment. The purpose of this

[1]I wish to thank Optical Data Corp., Oregon City High School, and particularly George Cashdollar for their assistance in this research.

paper is to examine the effect on attitudes toward science and technology of an environment designed specifically for encouraging girls as well as boys to learn to use multimedia technology within a science class. In the process other factors postulated to have an impact on attitudes are considered as well and a model for more adequately explaining participation proposed.

Theoretical Background: Many factors have been identified to account for the differences in the achievement of females and males in science, mathematics and technology, ranging from differences in abilities for the two sexes to biases in the general societal milieu (Benbow & Stanley, 1980; Matyas, 1985; Simpson & Oliver, 1990; Ertmer et al., 1994; Leder, 1990). Since females perform at least as well as males in coursework into college (Adelman, 1991; Kimball, 1989), most discussion in these fields has highlighted the role of the environment in creating differences in attitudes and participation, and consequently in attainment. While much of the empirical work does not explicitly invoke a causal sequence, the general argument suggests that, because of gender-role stereotyping in society, girls incorporate sexist beliefs about these disciplines, such as the idea that they are male domains and not useful for women's lives (Chen, 1986; Kahle & Meece, 1994; Campbell, 1989; Koohang, 1989). In addition, biased attitudes and expectations toward females on the part of parents, teachers and others (Kahle & Meece, 1994; Gerver, 1989) result in the creation of an environment that is not encouraging for girls. The consequence is differences between the sexes in interest and sense of efficacy. Once established, these attitudes affect the willingness of girls to participate in relevant experiences such as classes, camps, or even casual play opportunities. Without experience, girls' chances to develop their skills and advance their interest and confidence to the same extent as boys are limited. The cycle culminates in fewer women pursuing careers in these areas.

More specific theoretical models that incorporate these variables have been constructed by Fennema and Peterson (1985) in mathematics, in science by Kahle's group (Kahle et al., 1993), and by Eccles and her colleagues for general academic choice (Eccles et al., 1985). And there is empirical support for many of the postulated relationships (Simpson & Oliver, 1990; Kahle & Meece, 1994). However, there have also been conflicting results that raise questions about the sequence as a whole (Kimball, 1989; Meyer & Koehler, (1990); Brush, 1980). Two of the most important variables, and ones that can be directly addressed in educational institutions, are the amount of experience with these subject areas, and the quality of that experience (Ertmer et al., 1994). There is good empirical evidence in the area of technology that experience is strongly related to a sense of confidence and comfort (Loyd & Loyd, 1988). With careful structuring, girls participate equally (Arch & Cummins, 1989), and male and female interest tends to be similar when extent of prior experience is controlled (Chen, 1986). However, there is also contrary evidence indicating that even with equal experience, girls continue to be less enthusiastic about computers and science (Badagliacco, 1990) and to feel less efficacious than boys (Chen, 1986).

To account for this, attention has turned to the quality of the experience for the two sexes, hypothesizing that the structure of the classroom and the nature of the interaction there at worst replicate the biases found in the rest of society, or, at the least, are more conducive to a positive response by the boys (Kimball, 1989). Girls do tend to respond more positively to a different style of teaching than has been traditional in science education. A more cooperative and interactive context and a teacher who is warmer and more supportive contribute to greater learning and more positive attitudes in girls (Johnson et al., 1985; Kahle, 1985). It follows then that if girls and boys are placed in a situation that is supportive for the girls and provided with the same experiences in technology and science, they will become equally interested in the subject areas and equally confident in their abilities. While some research is emerging that explores the effects of the quality of experiences on attitudes (Ertmer et al., 1994), there is little on the results for differences in the attitudes and choices of females and males. This study was designed to determine whether establishing an environment that conforms to standards for sex equity would produce equal outcomes for girls and boys in their attitudes toward technology, science, and their own competence, as well as in their willingness to engage in subsequent opportunities to use multimedia technology.

Methods and Data Source: As a result of a grant from Optical Data Corporation, a project was launched in a suburban high school in the Pacific Northwest to introduce boys and girls to the use of multimedia technology within the context of a project-based, cooperative, student-centered biology course. Two classes with a total of 65 sophomores, juniors, and seniors received careful, extensive instruction in the use of the technical equipment as a resource for gathering information and for generating and testing hypotheses. The teacher was known for being particularly supportive of students, and encouraged risk-taking using the equipment. The school, the district, and Optical Data were united in their concern about the need to incorporate technological knowledge into education at the high school level and the need particularly to encourage girls to be sufficiently interested and confident to pursue science and technology-based careers.

At the beginning of the school year, students completed questionnaires about their attitudes toward computers and science, their prior experience with computers, and their sense of efficacy in learning the new technology (Bandura, 1988; Arch, 1992b). They also completed the Bem Scale of Masculinity/Femininity (Bem, 1974), with the Masculinity scores serving as the basis for ranking the students by "dominance" level. Students were then placed into groups of four by same sex and similar dominance score, to ensure that all students would be operating in a context where they could feel comfortable and efficacious. For the first nine weeks of the term, these groups engaged in cooperative science activities that incorporated learning the use of the multimedia technology. After that, cooperative groups were formed on a random basis and rotated periodically for different activities and projects that included extensive opportunities to use videodisk players and barcode readers as well as computers to access information and organize reports. Every aspect of the class was carefully constructed to ensure sufficient instruction and support so that all students would be successful with the equipment. The class also conformed to the guidelines for a sex-equitable classroom. Specifically, there was extensive use of laboratory work and discussion; choice and non-rule driven ways to accomplish learning goals were emphasized; and girls were directly involving in activities, with particular attention to preventing their domination by the boys as well as any disparaging language and behavior (Kahle, 1985).

Twice during the year, students indicated how efficacious they were feeling about using the equipment. Then, at the end of the course, they repeated the questionnaires about their sense of efficacy and their attitude toward science and computers. In addition, they indicated their future plans and reactions to the pace, organization, and emphasis of the class. Analyses and comparison of responses on the different instruments form the basis for the conclusions drawn.

Measures: Attitudes towards computers were assessed using the Computer Attitude Scale (Richards et al., 1986), a 23 item, 5-point Likert-scale instrument (1 = *Completely false* and 5 = *Completely true*) with 3 subscales designed to measure liking of computers (including liking and wanting to use, confidence in ability, comfort with the machines), computers as a male domain, and the value of computers for future endeavors. Negative items were reverse-scored and the item responses within each subscale averaged to get the subscale score. A Survey on Science instrument (Optical Data Corporation) was used to assess Attitude towards Science and Science Competence. This was a 31 item, 5-point Likert scale instrument (1 = *Strongly Disagree* and 5 = *Strongly Agree*) with 5 subscales, only two of which were used.

Demographic information, prior experience with science and computers, enjoyment of the course, and future plans were assessed through investigator-designed initial and final questionnaires. A separate instrument elicited responses on interest, self-efficacy (task, cognitive control and affective control), and anxiety using Likert-scale items (1 = *Not at All* and 5 = *Very*) (Bandura, 1977; Arch, 1992ab). The instructions on this form at the beginning of the year asked about responses toward using the technical equipment during the coming year, while the final administration asked how interested, confident, nervous, etc. the students were about using the equipment on their own in the future. The two administrations during the year had instructions appropriate to current uses in the classroom.

The value of the multimedia equipment was assessed through averaging the responses to five questions on the extent to which its use increased understanding in the science class. Prior experience with computers was measured through a scale constructed from questions asking whether the student had a computer in the home (Yes = 1), word-processed most papers (Yes = 1), and could use common computer applications with a moderate degree of efficiency (word processing, graphics, data base management, spread sheets, LOGO, auto cad, CIS. One use = 1, more than one use = 2). Final grades were also obtained for each student.

Analyses: ANOVA, Pearson correlation coefficients, multiple regression, and *t*-tests were used to analyze the relationships between the variables when appropriate.

Caveat: Because of various changes during the school year, none of which was directly related to the content or structure of the course, only 42 students (30 girls and 12 boys) completed all instruments. Because of the small sample, the conclusions drawn are very tentative.

Results and Discussion. Mean scores on the measures of attitudes before and after the course are presented in Table 1 for all students, and for females and males separately. As can be seen from the means for the entire group, general liking of computers went up significantly over the year. There was a significant increase in confidence about doing a good job with the equipment and about being able to control worry (cognitive control efficacy), and a decline in nervousness. Also, students at the end of the year strongly supported statements about enjoying the equipment and finding it valuable. And they indicated enjoyment of the science class. It would appear that the class was generally successful in encouraging students to use multimedia technology in the process of learning biology.

However, the issue is whether the experiencing of a sex-equitable environment for learning multimedia technology and science would result in similar attitudes for female and male students. And as can be seen from the data at the end of the year, here the results are not as encouraging. While the girls enjoyed the class and did well, their liking of computers and science and their sense of confidence that they could do a good job with the equipment did not increase to the same extent as the boys or even declined slightly, leading to significant differences between the two sexes by the end of the course. It would appear from this that not only did an equitable opportunity not lead to equality of outcomes but it did not even necessarily lead to equal gains in attitude, that is, where the girls continue to be behind the boys simply because they start behind. Instead, the boys responded more positively than the

Table 1: Comparison of Responses Before and After the Science Course

Means for Scales on Questionnaires (5 high)

	Pre			Post		
	Total	Girls	Boys	Total	Girls	Boys
Like computers	3.62	3.57	3.70	4.01#	3.90	4.30*
Computers as a male domain	1.45	1.35	1.67*	1.32	1.26	1.82*
Computers valuable for future	4.17	4.23	4.06	4.29	4.44	4.10
Interest in using the equipment	3.92	3.59	4.53*	3.98	3.80	4.42
Confident can do a good job	3.76	3.63	4.00	4.24#	4.00	4.83*
How nervous feel	2.18	2.44	1.71*	1.83	1.9	1.67
Cognitive control efficacy	3.80	3.53	4.29*	4.29#	4.27	4.33
Affective control efficacy	4.27	4.06	4.65*	4.57	4.5	4.75
Like science	3.36	3.34	3.39	3.35	3.19	3.78*
Feel competent in science	3.59	3.60	3.60	3.55	3.43	3.87*
Enjoyed using equipment				4.19	4.1	4.42
Value for learning in science class				3.76	3.63	4.08
Enjoyed science class				4.34	4.24	4.58
Willing to use multimedia equipment in future if given a chance				4.33	4.17	4.75*
Prior computing experience (4 high)	2.34	2.28	2.44			
Grades (Percent)				-	86.0	84.3

\# Pre/post is significantly different $p < .01$
* Girls and boys significantly different $p < .05$

girls to the opportunity, leading to greater differences between the two sexes in some areas. Perhaps most pertinent here is the evidence that at the end of the course there is a significant difference between the boys and the girls in the extent to which they say they are willing to use multimedia equipment in the future if given a chance. These results are not what would be expected when attention has been paid specifically to providing an experience where both girls and boys are comfortable and competent.

It is possible, of course, that the environment constructed in these classes was not really "girl" friendly, despite all efforts. However, enjoyment of the class was quite high. Fears were calmed. The attitude that computers are valuable for future endeavors remained high. In addition, grades in the class and the teacher's perceptions of the girls and the boys indicated little difference between them, if not some advantage for the girls in terms of competence with the technology. And while it is possible to claim that the presence of some other features in the classroom would have been beneficial, there is little research evidence to suggest what those features might be. The teacher was a male, and it has been proposed that girls need female role models as a base for a sense of their own power and potential. However, the importance of this factor has not been generally supported (*Nature*, 1994; Matyas, 1985). Here the teacher initiated this study with the hope of producing a very positive result for girls. If it is the case, given the overall positive results and the determination and care of the teacher, that the classroom actually was not as encouraging a one in general for the girls as for the boys, then the environmental factors that ensure equity would appear to be so subtle and so fragile as to make it unlikely that a widespread effort to institute the "right" environment could be possible.

However, while it may be difficult to conclude that the quality of the classroom experience was the cause of the unequal outcomes in attitudes, it still can be argued that, because of societal biases, girls and boys may have entered the course with sufficiently different experiences and attitudes that one year of encouragement and equitable treatment could not have a significant impact. Yet, for these students, this too does not seem to be a tenable explanation for the persistent differences. First, there was little difference in the means for reported level of prior computer experience. And, importantly, this variable had no relationship for the girls to any of the initial attitude variables (except for a moderate significant correlation with anxiety, $r = -.363$, $p < .05$). In other words, previous experience with computers was not linked to interest or sense of efficacy in engaging the new technology, nor to liking or valuing computers at the beginning of the year. It was also not related to subsequent enjoyment of the course or to grades.

Second, initial general attitudes toward computers were very similar for the girls and boys, both in feeling positive toward using them and in seeing them as having value for future endeavors. With the latter variable, it is noteworthy that on average the girls were more positive than the boys. This has not been found to be true in previous studies of attitudes toward mathematics, technology, and science. But perception of usefulness has been strongly linked to differences in participation and achievement (Meyer & Koehler, 1990, Koohang, 1989; Kahle & Meece, 1994; Eccles, 1983, Brush, 1980). Here, with a higher valuation of technology, girls would be expected generally to be more interested and willing to participate. Since that was not the case, the role of attitudes about usefulness for women's lives in predicting participation for girls has to be questioned.

Third, there was a significant difference at the beginning of the year between boys and girls on the scale tapping whether computers are perceived as a male domain. This persisted at the end of the year, raising the possibility, as has been postulated (Meyer & Koehler, 1990), that gender-role stereotypes are affecting enthusiasm for computers. However, the means for both the boys and the girls, pre- and post-measures, were between "Completely false" and "False much of the time" on a 5-point scale, with the girls lower than the boys. In other words, support for these statements was at such a low level, particularly for the girls, that explaining sex differences by sex-role congruency, where girls do not see technology use as appropriate for their sex role, is not very tenable (c.f. Brush, 1980). Further, there were similar means for girls (4.9) and boys (5.0) on the Bem Masculinity Scale, indicating that the girls on average did not come into the class feeling less assertive than the boys. And, at the beginning of the year, the girls were not significantly less confident in their ability to do a good job than the boys.

Finally, almost all the students had had science the previous year (girls: 92%, boys: 87%). And the lack of any initial differences between the two sexes in their liking of science or their feelings of competence in science makes it difficult to conclude that the differences at the end of the course were a consequence of what the students had experienced before the course rather than a response to what occurred during the study year.

However, there were some factors with important differences between the sexes at the beginning of the year that need to be examined. Despite the generally similar attitudes towards computers and their own task efficacy, the boys and the girls at the beginning of the term were different in their sense of how nervous using the multimedia technology would make them feel, and how confident they were in being able to control their worrying (cognitive control efficacy) and nervousness (affective control efficacy) enough to do a good job working with the new equipment. This initial more negative affective response and lower efficacy on the part of the girls could be the basis for differential experiences during the year. Yet, in actuality, as is evident from the post-assessment, the course had a definite positive impact on these factors, bringing the girls' averages closer to the boys. These data suggest that the differences in responses that might be attributed to differences in prior experiences were amenable to the impact of this one year, in a positive direction.

It was only in the responses to the question on interest in using the equipment that an initial significant difference between girls and boys persisted, being only somewhat reduced during the course. Initial interest did correlate for the girls with initial liking of computers ($r = .631$, $p < .0001$), task efficacy ($r = .573$, $p < .001$), and anxiety ($r = -.376$, $p < .05$), so less interest is related to entering the course with less positive attitudes toward computers and toward one's own ability. However, the correlation of prior interest with interest at the end of the course was not particularly high ($r = .39$, $p < .05$) indicating that while girls are less interested than the boys at both times, it is not necessarily the same girls who are at the lower end of the ratings.

This same shifting can be seen in Table 2 for the group as a whole in the relatively low correlations between the pre- and post-measures for the attitude variables tied specifically to this experience, even though the correlations for the more general measures of attitudes toward computers and science were high. This suggests that it is worth examining the responses of some of the individuals for whom this year-long experience in science and technology clearly changed their attitudes to see whether the patterns are similar for girls and boys. There was only one boy for whom the innovative science course did not lead to substantial interest or willingness to use the multimedia equipment in the future. On the other hand, there were a group of 5 girls who reported they were only somewhat willing to use the equipment in the future (with 9 others who indicated they were somewhat to not-at-all interested in using the equipment). There was also one boy who came into the course with low engagement and ended the year with high willingness while several of the girls had a similar pattern. Table 3 provides the patterns of responses to the variables for the two boys and two of each type of girl.

The first boy, who will be called Mike, was most clear in his responses. He entered the class liking computers and science, being interested and confidence about the possibility of using the multimedia technology. He did well in the course. But by the end, although he still professed to like computers and science, and to feel confident he could do a good job with the equipment, he was just not interested. He did not enjoy using the equipment and did not find it valuable for his learning. And he was not particularly willing to use it in the future if given a chance.

Michelle and Maggie also ended up not being particularly willing to use the equipment, but their stories are a bit more complex, with more concern about their internal responses and their ability to cope with those (Arch, 1992). Michelle enjoyed using the equipment. She is more interested in it than at the beginning of the course. However, she lost some of her

Table 2: Correlations Between Variables Before and After the Course

Like science	.67
Like computers	.65
Feel competent in science	.59
Computers valuable for future	.47
Confident can do a good job	.47
Interest in using multimedia equipment	.37
Cognitive control efficacy	.37
Computers as a male domain	.35
Affective control efficacy	.30
How nervous feel	.27

Table 3: Responses of Individual Students

	Mike Pre	Mike Pst	Michelle Pre	Michelle Pst	Maggie Pre	Maggie Pst	Greg Pre	Greg Pst	Gina Pre	Gina Pst	Giselle Pre	Giselle Pst
Like computers	4.8	5.0	3.8	4.0	4.6	3.1	2.8	3.8	3.6	3.6	3.8	3.5
Computers as a male domain	1.0	1.0	1.2	3.0	1.8	2.2	3.6	1.8	1.0	1.0	1.8	1.0
Computers valuable for future	5.0	5.0	4.7	4.5	4.8	3.8	4.2	3.5	4.8	5.0	4.0	4.5
Interest in using the equipment	5	2	3	4	5	4	4	5	1	4	2	4
Confident can do a good job	5	5	4	3	4	1	4	5	2	4	3	5
How nervous feel	1	1	2	2	3	5	1	1	3	2	2	1
Cognitive control efficacy	5	5	4	3	3	1	3	2	3	4	4	5
Affective control efficacy	5	5	4	2	4	3	5	3	2	4	3	5
Like science	4.6	5.0	3.6	3.2	2.2	1.8	2.8	2.8	2.8	3.6	2.8	2.4
Feel competent in science	4.1	4.9	3.8	3.5	4.6	2.4	3.1	2.6	4.1	3.0	3.5	3.3
Enjoyed using equipment		2		4		2		5		3		3
Value for learning in science		2.2		3.4		1.7		3.8		3.5		3.3
Enjoyed science class		5		4		3		4		3		4
Willing to use multimedia equipment in future		3		3		3		4		4		4
Prior computing exper. (4 high)	2		4		2		4		1		4	
Grades (Percent)		89		88		83		81		93		72

confidence that she could do a good job with it, and was less sure she could control her worry and nervousness enough to do so. For her, computers have become something that appeals to boys more than girls. The other girl, Maggie, had even more concern about her anxious responses to the equipment and was not at all sure she could control her worrying and do a good job. She did not start that way, but during the term she found that she did not enjoy using the equipment and did not find it valuable for her learning. It would seem unlikely that she or the other two would actively seek out opportunities to use the equipment on their own in the future.

In contrast, Greg started the year with only a moderate interest in computers. He does not particularly like science, or do well in it. However, he found he liked the technology a great deal, and became very interested in using it. Gina and Giselle both started with particularly low interest in using the equipment and with little sense of efficacy, either to do the task, or to control their own nervousness and worry. However, by the end of the term, while Gina was successful in the class and Giselle not, they were both quite interested and confident in using the techology. They would be willing to use the equipment in the future.

It is apparent that the experience of this science class led some students to change in their confidence and interest from where they started at the beginning of the year. It is also apparent that the attitudes that result from this experience are strong predictors of willingness to use the equipment in the future. Multiple regression analysis was performed using Grades, Computers as a male domain, Liking for computers, Value of multimedia equipment for learning science, Efficacy (created from questions about task, affective control, cognitive control efficacy and anxiety), and Interest as predictors. The results shown in Table 4 indicate that 74% of the variance in Willingness to use the multimedia technology in the future is accounted for, with Efficacy and Interest the only variables with significant coefficients.

To summarize, the results from this study indicate that difference between boys and girls in average attitudes toward technology and science persist despite careful attempts to improve the quality of the experience for girls. It is evident that prior experiences colored by societal biases are not leading to a generally less positive response to this experience by the girls. And at least in this milieu, the explanation that unequal or biased instructional practices are the reason for continuation of sex differences, with the conclusion that changes in practice can alleviate the differences, is not tenable. During the course some found the experience to be interesting and positive, while for others it was not as positive as they expected. And their level of confidence and interest translated into willingness to use the equipment in the future if given an opportunity. What is pertinent is that here, as in other studies (Collis, 1985, Chen, 1986), the percentage of the girls who found the multimedia technology in the science class

Table 4: Regression Coefficients for the Effects of the Independent Variables on Willingness to Use Multimedia Equipment in the Future.

Independent Variables		
Efficacy	.47	$p<.01$
Interest	.37	$p<.05$
Like computers	.33	
Computers as male domain	-.21	
Equipment positive for learning	.14	
Performance (Grades)	-.07	

R .86 $p<.0001$ ($R^2 = .74$)

somewhat less compelling is higher than the boys. The fact that there was another subset of girls who reported considerable interest, who felt as comfortable and confident as the most interested boys, and who stated they would be very willing to use the equipment in the future if given a chance indicates that whatever contributed to the less than enthusiastic response on the part of some of the girls was not a general characteristic of the class, a bias leading the girls to find this opportunity to be a negative one for their interest and sense of self-confidence. Instead, the course seems to be impacting individuals differently. And it is in this direction that explanations must be sought.

Conclusions and a model for explaining differences in willingness to pursue further experiences: This study produced results that, like other studies, do not clearly support previous explanatory models for sex differences in attitudes and choices in mathematics, science and technology (Meyer and Koehler, 1990; Kimball, 1989; Brush, 1980; Kahle & Meese, 1994, Fennema, 1983). Without evidence for particular bias against girls, and with evidence that experiences in science and technology are received differently by individual students, the focus of inquiry into the bases for sex differences in involvement with these fields may need to shift from the general effects of societal pressures to intra-individual differences in response to these opportunities (Eccles, 1987). This shift in focus means greater emphasis needs to be put on the characteristics individuals bring to experiences that then become clarified and specified to the individuals through those experiences, and lead to different choices of activities. With the obvious caveat that the environment can distort and restrict what is concluded about experiences and about the self, there still seems to be a decision on the part of the individual about the extent to which some activities and subjects "fit" with her or his own characteristics. Therefore, a model is proposed here that has as its major focus the information about the self most salient to individuals when they conclude that some experiences are worthy of continued pursuit, while other opportunities are less compelling (See Figure 1).

Actual ability would certainly affect what is determined to fit with one's self. However, while there is evidence for sex differences in mathematics ability (Benbow & Stanley, 1980), and ability is a consistent predictor of level of course plans in that area (Brush, 1980), in science and technology it is difficult to specify the particular capabilities required and therefore what information is being used. And in all these fields, differences in interest are apparent between boys and girls even when ability is taken into account. As Fennema noted: "The problem with girls is not the ability to learn mathematics, but the willingness to study mathematics"(Chen, 1986).

Figure 1: Model for Relationship between Variables Predicting Continued Participation

INDIVIDUAL	ENVIRONMENTAL OPPORTUNITIES*	CHOICE
Cognitive Fit e.g. a. Abilities b. Intrinsic interests (The stronger these are, the more likely the individual is to pursue specific activities without regard for particular environmental constraints)	>>Willingness and Interest	>>"Specialize in what are good at" >>"Create conditions that suit self"
Affective Responses e.g. a. Likelihood of anxious responses b. Ability to cope with anxious responses c. Responsiveness to other's opinions		
Personal Characteristics e.g. a. Tendency to see abilities in positive light b. Willingness to take risks		

*Experience provides information about individual variables, particularly in comparison with others.
*Experience also indicates what opportunities are available to use talents (these can be restricted by gender and racial stereotypes, economic limitations, chance)
*Experience can undermine all aspects of self if consistently negative.

Given opportunities and choice, the primary impetus for decisions about whether to participate and persist is from within the individual.

It is also obvious from these data and others that the objective outcomes of participation, e.g. performance measures such as grades, are not necessarily indicative of the extent to which individuals find themselves engaged and eager to pursue a field. In this study interest and willingness were not related to grades. In fact, the average grades for the girls least interested was slightly higher than the general average, and the least interested boy also performed well. Numerous other research results indicate that even with no differences in achievement in the classroom and no difference in teachers' assessment of competence or comfort, girls still are less confident, giving lower estimates of future success, the variable crucial for persistence in a field (Meyer & Koehler, 1990; Chen, 1986; Kimball, 1989). Eccles (1983) has noted that it is perceived ability rather than objective measures of ability that relate to interest in further work. However, the question of what information is being used to form these conclusions about the self still remains.

Perhaps the evidence of ability that is being utilized internally by the individual is the attribute captured in questions about "ease" of performance. Males have on average reported finding mathematics "easier," even in situations with no reported sex differences in general liking and interest (Brush, 1980), and where both sexes achieve equally. They also are significantly higher in perception of natural talent in math, although they tended to over-estimate their ability (Bornholt et al., 1994), a personal characteristic that may serve them well. The same has been reported in relation to physical science topics, even where observers see no evidence for greater ease or competence (Kahle et al., 1993). It would appear that the pertinent information to individuals about their abilities may come from the doing, not just the outcome, and that this internal conclusion is not manifested in any particular overt manner that others can observe.[2]

A related factor contributing to individuals' conclusions about whether a subject fits their cognitive abilities is perceived effort (Eccles et al., 1985). With good effort it is possible to do well, even though a task is not particularly compelling. However, the more effort required, the more the attribution of the cause of success is to that effort: the conclusion drawn is that one is not particularly good at this task(Bornholt et al., 1994), even if it is generally valued. And the outcome is likely to be less interest in persisting in that field. While females are more motivated to achieve than males (Simpson & Oliver, 1990) and perform well, they are more likely than males in general to attribute success to effort, and in particular to indicate higher effort in mathematics than English (Fennema, 1985; Brush, 1980). This would contribute to more females deciding to pursue the latter field rather than the former.

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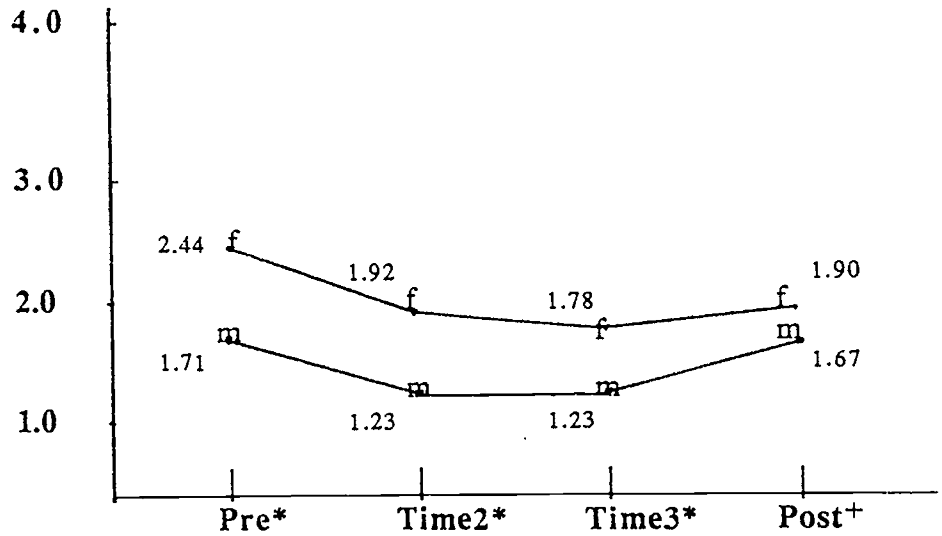
[2]Although standardized achievement test scores may reflect this since they are not tied to specific content where effort can make a difference (ETS, 1991; Kimball, 1989; Kahle & Meece, 1994).

Figure 2: Mean Responses to Questions about How Nervous Using the Equipment Makes Feel, By Girls and Boys



*Males and females significantly different p <.05

+Question on post-measure asked students about how nervous they would be using the equipment on their own in the future.

In addition to ability, there is another factor indicative of cognitive fit, a variable that captures the sense of some activities' being more "compelling" than others. That is personal interest. Deci (1992) looks at interest as evidence of intrinsic motivation, the basis of self-determined activity "of interest to one's intrinsic self and ... thus freely undertaken" (p. 44). Interest can be generated within a situation and lead to individual commitment to continue involvement in an area (Hidi, 1990). However, experience does not necessarily have this result, indicating that some things just inherently fit better with some individuals' "intrinsic" selves and not with others. In terms of explaining average sex differences, this suggests there may simply be differences in personal interest in response to opportunities in technology and science, with more boys finding themselves "intrinsically" interested (although certainly not all) and fewer girls (although certainly some).[3]

Besides clarifying cognitive fit, a particular activity may provide information to individuals about their affective responses to participation in a field and their ability to control those responses enough to do a good job. Females seem to respond anxiously more than males generally (Maccoby & Jacklin, 1974), and report greater anxiety when involved in science, mathematics, and technology (Brush, 1980; Chen, 1986). For example, it is quite clear in Kahle et al. (1993) that confidence in science ability for girls is linked specifically to fear of making a mistake: "I might put the wrong thing in the bottles." "I would make a lot of mistakes." "If I was doing an experiment, I would put the wrong potion in." "I am so dumb that I would mess everything up" (p. 390). Mathematics, science, and technology tend to stress right answers and procedures, and the errors can be highly visable. As a consequence, females may be less willing to take the risks that lead to real engagement (Licht & Dweck, 1983; Arch 1993).

Further, Bandura (1977) noted that the greater the sense of efficacy, the less the anxiety. And this is supported by the data from this study as experience with the technology grows. Yet, as can be seen in Figure 2 that tracks how nervous using the multimedia equipment makes students feels, anxiety was reduced during the year with experience and increased confidence, but when anticipating how anxious they would be in the future, the average response went up again. If females are more likely to respond anxiously to prospective opportunities, to the thought of trying something new (Kimball, 1989), fewer will decide to pursue those opportunities. In addition, an important component of self-efficacy, especially for females (Arch, 1992a), is confidence in one's ability to control anxiety enough

[3]Interestedly, in this study the grades for the boys in a comparable, non-technology focused science class were considerably lower (this is more typical, since girls tend to do better in science coursework (Kahle & Meece, 1994)), raising the possibility that over and above any differences in interest in biological science, the introduction of the technology was particularly attractive to the boys, creating a positive response in more of them that translated into better course grades.

to do a good job. The lack of such confidence would also contribute to the decision that a particular subject area does not "fit" with one's intrinsic self.

What is being suggested is a different model than is currently accepted to explain the origins of sex differences in average attainment in various fields, one that puts the individual's abilities and characteristics first in the sequence, and most primary for determining willingness to participate. As the model indicates, opportunities and encouragement will provide the specific content of interests, and the specific directions that are possible to take. However, this information is used internally to hone understanding of one's own abilities and interests that then affect choices of future activities. The farther along in school and life, the freer of parental and societal dictates individuals become and the more they must decide about how to spend their lives (Scarr & McCartney, 1983). The cumulation of the conclusions about one's own interests and abilities, resulting from the experience of doing, will weigh heavily in those choices. It seems obvious that, when given a choice, individuals will not choose to do something they have found takes effort, appears to them to be something at which they are not particularly good, fails to capture their interest, and raises anxiety and questions about coping. If fewer girls than boys have found themselves interested and comfortable in particular areas despite encouragement and successful outcomes, than fewer will pursue those fields.

This does not suggest that no efforts should be made to encourage all to participate and to be confident.[4] Certainly, any efforts to generate interest, reduce anxiety, and build efficacy can lead only to more girls and boys deciding to participate in further opportunities in science, technology, and mathematics. However, former arguments have put too little emphasis on the effects of individual characteristics, abilities, and interests. As was evident in this study, not all will respond in the same way to the same opportunities no matter how carefully constructed; equity of opportunity and encouragement will not necessarily lead to equality. To attribute difference in response primarily to environmental bias would appear to be misguided. Instead, attention to personal interests, to the individual's sense of "fit," may make disparate research results more intelligible and lead to an educational process designed to serve the needs of each girl and boy more effectively. The point is that many of the differences in what people do occur because individuals are interested in and eager to pursue different things. It is the Baldwin[5] effect -- "people specialize in what they are good at and so create conditions that suit [them]" (Ridley, 1993, p. 252). It is a matter of choice.

[4]Clearly, the factors involved are complex, with differential effects for different cultural groups and socioeconomic levels (Meece & Eccles, 1993; Sutton, 1991).
[5]Psychologist James M. Baldwin, 1861-1934.

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