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Gender Patterns in Science Course Enrollment and Course Drop Patterns in an Iowa Senior High School

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In order to ascertain whether local patterns corresponded to the national trends, which show fewer female and minority students enrolling in and completing high school physical science courses, the Cedar Rapids Community School District studied the course enrollment and drop patterns of seniors in one of the District high schools. Male students predominated in physics and AP Chemistry, and the proportion of males in AP Physics was significantly greater than the proportion of females. The proportion of females in chemistry was significantly greater than their proportion in the senior class. Course dropping patterns revealed a statistically significant relationship between gender and course dropping, as well as in course completion. As a result of these findings, intervention strategies have been implemented to increase female students' persistence in science course completion.
INDEX DESCRIPTORS: gender equity, science course enrollment.

The number of students preparing to become scientists and engineers decreases as students progress through school. Nationally, of the 4,000,000 high school sophomores in 1977, only 5% earned a college degree in science or engineering in 1984 (Task Force, 1988). In 1989-90, according to data from the National Assessment of Educational Progress, among 17-year-olds, 87% of the females and 82% of the males took one or more years of biology, but only 45% of the females and 40% of the males took chemistry. The further attrition in students enrolled in science was revealed by the fact that only 9% of the females and 12% of the males took physics (Digest, 1993).

At the national level in 1990, fewer students were taking Advanced Placement (AP) physical science courses than were taking AP Biology: AP Biology, 32,643; AP Chemistry, 19,289; AP Physics, 8,826. Gender representation varied within the courses. More females (n=16,983; 52.03%) than males (n=15,660; 47.97%) took AP Biology. However, more males than females took AP Chemistry (F=6,575, 34.09%; M=12,714, 65.91%). A similar but more pronounced underrepresentation of females was evident in AP Physics: female, n=2,366 (26.81%); male, n=6,460 (73.19%) (College Entrance Examination Board, 1990).

By 1992 nationally, the overall proportion of students taking laboratory sciences had increased, but, as in previous years, fewer students took upper level physical science courses and gender distribution was similar to 1989-90. Among 17-year-olds, 93% of the females and 91% of the males had taken one or more years of biology, but 54% of the females and 47% of the males had taken chemistry, and 12% of the females and 15% of the males had taken physics (Digest, 1994).

A 1992 survey of 1,250 schools and 6,000 teachers, sponsored by the National Science Foundation and conducted by Horizon Research, Inc. (Weiss, Matti & Smith, 1993), reported the proportions of females and males *within* the laboratory sciences. The proportions of females within biology and chemistry courses was somewhat greater than that of males: biology, females (54%), males (46%); chemistry, females (52%), males (48%). But males predominated within physics courses (female, 41%; male, 59%).

Hulme and Smith (1988) summarize some of the national trends as follows: "As students approach the physical sciences in their junior and senior year of high school and as they proceed into college two trends appear. First, the majority of American students, both male and female, drop out of science; and second, the dropout rate for females far exceeds the rate for males except in the social and life sciences" (p. 124). Other authors confirm these two patterns (Kahle, 1985; National Science Foundation, 1988; Carelli, 1988; Krieger, 1990).

The relatively small number of students in upper level science courses could result in a shortage of American students being adequately prepared to lead the nation forward in science and technology in the coming decades (Office of Technology Assessment, 1988; Vetter, 1993). The patterns among young women are of particular importance since by the year 2000, "two thirds of all new entrants [into the work force] will be women of all races, minority men or immigrants " (Vetter, 1993, p. 4).

To some degree, these national patterns have been documented in the state of Iowa. According to Myrna Whigham (1990a), of the students earning degrees at Iowa State University in the engineering disciplines and all the physical sciences, the disproportion between female and male students was greater than in 10 comparable institutions in other states. Dr. Whigham (1990b) also reported Iowa Department of Education statistics showing that, although 36,670 Iowa students took high school biology in 1988-89, only half that number took chemistry (18,333), and fewer took physics (9,415). The enrollments in 1989-90 were similar to the previous year: (chemistry, 18,329; physics, 9,022). These figures mirror the national pattern, that is, the number of students enrolled in the sciences decreases as the level of the science course increases.

With regard to gender enrollments, similar proportions of Iowa female/male students in 1988-89 were enrolled within chemistry courses (female, 50.0%, n=9,181; male, 49.92%, n=9,152), as they were in 1989-90 (female, 49%, n=9348; male, 51%, n=8981). However, as at the national level, males in 1988-89 comprised more of the physics enrollment (59.39%, n=5,592) than did the females (40.61%, n=3823), as they did in 1989-90 (male, 60.0%, n=5413; female, 40%, n=3609). These proportions were similar to the proportions reported in the previously noted 1992 national study by Weiss and her colleagues. In AP physical science courses in Iowa, the female/male distribution was as follows: AP Chemistry (female, 24.6%, n=14; male, 75.4%, n=43); AP Physics (female, 17.6%, n=6; male, 82.4%, n=28) (College Board, 1990). These Iowa Advanced Placement discrepancies were more pronounced than the discrepancies at the national level.

By 1993-94, the number of Iowa students in science courses had increased, but the gender distribution revealed discrepant patterns, especially in physics, according to the Iowa Department of Education: chemistry: female, 52.43%, (n=11,986), male, 47.57%, (n=10,874); physics: female, 42.99%, (n=4,756), male, 57.00%, (n=6,306). For AP courses the distribution was as follows: AP Chemistry (female, 34.6%, n=44; male, 65.4%, n=83); AP Physics

(female, 16.7%, n=7; male, 83.3%, n=35) (College Board, 1994). The 1993-94 AP Chemistry discrepancies had narrowed compared with 1990, but the 1993-94 AP Physics discrepancy remained relatively unchanged.

For several decades, investigators have documented the enrollment and achievement divergence in mathematics between girls and boys as early as in middle school years (Fennema & Sherman, 1977; Fox, 1977). If girls choose not to take mathematics when it is no longer required, this "math filter" not only precludes girls from gaining prerequisite skills for higher level math courses, but it also closes the gates on science and engineering courses where mathematics skills are essential.

Several research streams have explored possible explanations for girls underrepresentation in mathematics and science. Benbow and Stanley (1980) and, more recently Benbow (1988; 1992) have pursued biological, gender-linked factors that might relate to differential mathematics performance among highly intellectually gifted students. Considerable discussion has focused on this work (see, for example, Commentary on C. P. Benbow, 1988). Kimura (1988) and her colleague (Kimura & Hampson, 1994) have also explored biologically based factors for gender differences in certain cognitive tasks.

Another body of research focuses on social influences shaping students' attitudes toward mathematics and science and the effects of these attitudes on subsequent course-taking decisions. Building on the work of motivational and attribution theorists, e.g., Atkinson (1964) and Weiner (1974), Jacquelynne Eccles has developed a model that links course-taking decisions to the student's *expectations for success* in that domain and to the student's perceptions of the *value* of the task (Eccles et al., 1983; Eccles, Adler & Meece, 1984).

In this model expectations for success are based, in part, on students' estimates of their ability. Numerous studies report that girls tend to under estimate their ability in science and mathematics (e.g., Berndt & Miller, 1990; Feather, 1988). Since perceptions of ability predict plans to enroll in upper level math courses (Armstrong, 1985; Eccles, 1989), girls' underestimation of their ability helps to explain their lack of confidence in future success and their tendency not to persist in taking advanced courses in math and science.

The construct of task value has four components: 1) attainment value: or the importance of doing well on a task; 2) utility value: the importance of the task for the future; 3) intrinsic value: immediate enjoyment of the activity; 4) the cost: the effort needed to accomplish the task. If girls do not see the current or future value of science or if they perceive the cost (in effort) to be too great, they will tend not to enroll in math and science courses. "Cost" may take the form of having to overcome stereotypic beliefs about gender-appropriate occupations (Berryman, 1983; Eccles, 1989).

QUESTIONS

In order to discover whether these national and state trends exist at the local level, the Cedar Rapids Community School District examined advanced science course enrollment and drop patterns among seniors (Class of 1990) in one district high school. Of particular interest was the investigation of possible gender discrepancies in enrollment and course completion in the physical sciences. Under a grant from the FINE Educational Research Foundation, data was collected in 1989-90 to answer the following questions:

1. Is there a difference in the proportion of senior male and female students enrolling in upper level physical science courses?
2. Is the proportion of male and female students enrolled in upper level physical science courses representative of their respective proportions in the senior class?
3. Is there a relationship between gender and physical science course dropping?
4. At graduation, is there a relationship between gender and the completion of upper level physical science courses?

PROCEDURE

First term. Two weeks after the beginning of the first term , lists of seniors enrolled in chemistry, physics, Advanced Placement (AP) Chemistry, and AP Physics were developed and became the master tracking list for the year. From the lists, data tables were constructed to determine the proportion of senior males and females enrolled in each course.

Second and third terms. Two weeks after the end of the first and second terms, a class roster listing students grades for each course was used to identify students who had not completed the term. In addition, enrollment lists for the new terms were used to identify students who did not re-enroll. This data was analyzed for gender patterns in enrollment and course dropping over the three terms.

Science course completion. Graduating seniors' transcripts were analyzed to determine the number of males and females completing upper level physical science courses.

RESULTS

1. Proportion of Senior Class Male and Female Students Enrolled in Upper Level Physical Science Courses.

As shown in Figure 1, of all the seniors in the class of 1990 (males, n=204; females, n=168), only a small percentage were enrolled in advanced physical science courses (physics, AP Physics or AP Chemistry).

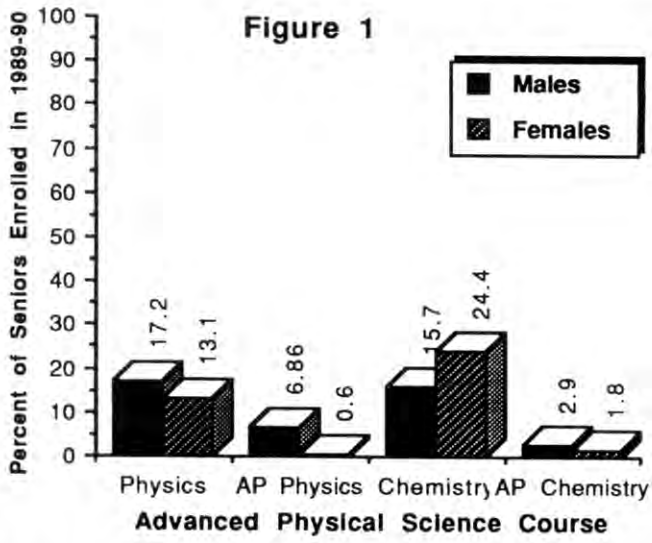

Figure 1: Percent of Seniors Enrolled in Physical Science Courses 1989-90

Although differences in the proportions of senior males and senior females are not statistically significant ($p<.01$) for chemistry[1], physics[2] and AP Chemistry[2], the data are indicative of males predominating in physics and AP Chemistry, and females predominating in chemistry. However, the proportion of senior

[1]Differences of Proportions Test Independent Samples
[2]Fisher's Exact Test for Small Samples

males in AP Physics[2] is significantly greater than the proportion of senior females ($p<.001$).

2. Proportion of males and females within physical science courses relative to their respective proportions in the senior class.

If the proportion of male and female students in upper level physical science courses reflected the composition of the senior class (n=372, females=168, males=204), 45.2% of those enrolled in a science course would be female and 54.8% would be male. The composition of seniors enrolled in physics (38.6% female to 61.4% male), AP Physics (6.7% female to 93.3% male), chemistry (56.2% female to 43.8% male) and AP Chemistry (33.3% female to 66.7% male), does not reflect these proportions. Except for chemistry, females are consistently underrepresented, as depicted in Figure 2.

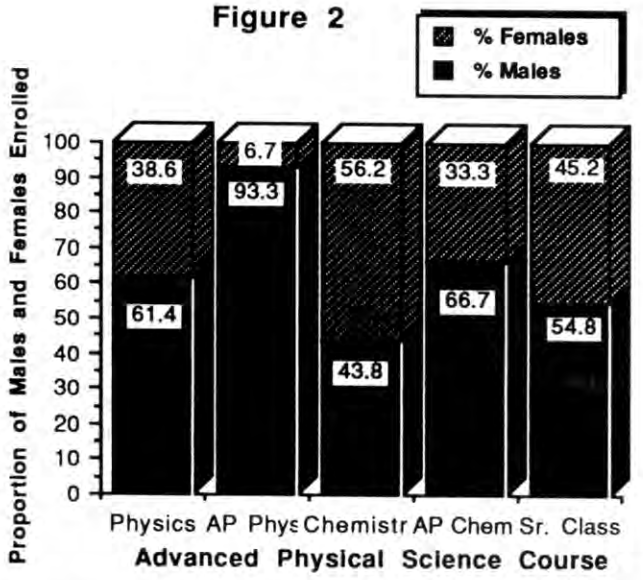

Figure 2: Percent of Males and Females Enrolled in Physical Science Courses Relative to Their Proportion in the Senior Class

Although the proportion of senior males in physics and AP Chemistry was greater than their presence in the senior class, and the proportion of senior females was less than their presence in the class as a whole, these differences in proportions were not statistically significant ($p<.05$)[3]. However, the proportion of senior females in chemistry was significantly greater than the proportion of females in the senior class ($p<.06$)[3]. In AP Physics, the proportion of senior males was significantly greater than their representation in the senior class ($p<.001$)[3].

3. Course drop-out patterns.

Many senior students dropped out of physical science courses. During the academic year, the number of seniors enrolled in chemistry dropped from 73 to 39; in physics from 57 to 46; in AP Chemistry from 9 to 7; in AP Physics from 15 to 14 (Table 1).

The proportion of seniors who dropped chemistry (34 out of 73 students who originally enrolled) was greater than the proportion who dropped other physical science courses.

While there was a tendency for a greater proportion of senior males than senior females to drop chemistry ($p<.15$)[4], and for a greater proportion of senior females than senior males to withdraw from physics ($p<.22$)[4], a statistically significant relationship between gender and course dropping was not established. However,

Table 1. Senior Students Dropping Science Courses from First to Third Trimester 1989-90

Course	Group: Total Enrolled	Total Dropped	Males Enrolled	Males Dropped	Females Enrolled	Females Dropped	p<
Chemistry	73	34	32	18	41	16	.15
AP Chemistry	9	2	6	0	3	2	.0236*
Physics	57	4	35	5	22	6	.22
AP Physics	15	1	14	0	1	1	.0258*

*$p<.05$

a statistically significant relationship existed between gender and course dropping for AP Physics ($p \geq .0258$)[5] and AP Chemistry ($p \geq .0236$)[5], with more females than males dropping.

4. Completion of Upper Level Physical Science Courses at Graduation.

Among the 204 males and 168 females who graduated in 1990, a slightly higher proportion of females than males as seniors completed chemistry, and more males than females completed AP Chemistry. These differences were not significant (chemistry, $p<.316$; AP Chemistry, $p<.103$)[4]. However, more males than females completed physics and AP Physics, and these differences in course completion patterns were significant (physics, $p<.001$; for AP Physics, $p<.005$)[4], as shown in Table 2.

Table 2. Percent of Seniors (Class of 1990) Completing Upper Level Physical Science Courses

Course	Group: Female (n=168) N	Female %	Male (n=204) N	Male %	p<
Chemistry	61	36.3%	64	31.4%	.316
Physics	20	11.9%	53	25.9%	.001**
AP Chemistry	3	1.8%	10	4.9%	.103
AP Physics	1	0.59%	13	6.4%	.005*

*$p<.01$ **$p<.001$

DISCUSSION

A direct comparison between the 1990 local and national data is not possible for the following reasons: 1) this study focused on seniors in one school in 1990; 2) the national data on enrollment reported "on 17-year-olds who took one or more years" of the courses being reported; and 3) the within-course national data came from a 1992 survey. However, some patterns are of interest. First, at the national, state and local levels, fewer students overall enrolled in

[2]Single Sample Test of Proportions Compared to Fixed Population
[3]Chi Square Test of Independence
[4]Unconditional Exact Test for Two x Two Binomial Tables

physics than in chemistry. Second, for Advanced Placement courses, in contrast to the 1990 national data on 17-year-old students, which showed more total students in AP Chemistry than AP Physics, a smaller proportion of local seniors was enrolled in AP Chemistry than in AP Physics. It is possible that in the local setting, some of these seniors had completed AP Chemistry as juniors, and were electing to take AP Physics as seniors. If the final transcripts of graduating seniors had been examined for courses taken throughout the high school career, rather than courses in the senior year, it is possible that the data would reveal that, at graduation, more students had completed AP Chemistry than AP Physics. An examination of this possibility is planned for graduates in the class of 1995.

Third, as shown in Table 3, with regard to gender representation *within courses*, a greater proportion of females than males enrolled in chemistry locally and at the national level. Fourth, a greater proportion of males than females enrolled at all three levels in physics, AP Chemistry and AP Physics.

In physics, the local proportion of females (38.6%) was relatively similar to that of the state (40.00%) and national (41%) levels. For AP Chemistry, the local female underrepresentation (33.3%) was less than at the state (24.6%) and similar to the national level (34.09%). Since 24.4% of local senior females were taking chemistry as seniors, they had eliminated the option of taking AP Chemistry as seniors in high school, Within AP Physics, a smaller proportion of local students were female (6.7%) than at the state (17.6%) and national (26.81%) levels. However, total 1990 Advanced Placement enrollments in this high school were relatively small, and consequently these comparisons across levels may be of little value. These enrollments will be re-examined for the class of 1995.

The national trend of fewer students taking upper level science courses is evidenced in this local study. Many senior students do not enroll in advanced science courses; of those who do enroll, many do not complete one year (three terms) of the course. Proportionately fewer female students enroll in and more female students drop advanced physical science courses than male students. Consequently, the loss of female students contributes to the diminishing cadre of students preparing for further training in science and technology.

The district is currently examining enrollment and drop trends among all the students enrolled in advanced science courses, not just the seniors. Preliminary data analysis reveals patterns similar to those identified for seniors.

A crucial determinant of student enrollment is the degree to which students see the relevance of science for their future (Eccles, Adler and Meece, 1984). Carefully planned instructional strategies can break down stereotypic views of female career options and increase awareness of the day-to-day value of science in careers (Kahle, 1985). These strategies can contribute to heightened student motivation to enroll and persist in high school science courses.

Consequently, the district is implementing a program to screen and schedule female scientists and engineers who will serve as role models in advanced science courses. The courses targeted for role model visits are those which are most likely to include students who will graduate in 1995. The role models, in describing their career preparation and current work, will assist students to see the application of concepts and processes they are studying. The role models will also demonstrate that females can be successful in scientific and technical fields. Subsequent research will assess the course completion and total science credits earned by males and females graduating from the same high school in 1995.

Table 3. Gender Distribution Within Upper Level Physical Science Courses

	National[1] 1992*		State[2] 1990		Local Seniors Only 1990	
Course	Female	Male	Female	Male	Female	Male
Chemistry	52%	48%	51%	49%	56.2%	43.8%
Physics	41%	59%	40%	60%	38.6%	61.4%

	National[3] 1990*		State[3] 1990		Local Seniors Only 1990	
Course	Female	Male	Female	Male	Female	Male
AP Chemistry	34.09%	65.91%	24.6%	75.4%	33.3%	66.7%
AP Physics	26.81%	73.19%	17.6%	82.4%	6.7%	93.7%

*Year for which national *within* course data could be located.
[1] Source: Weiss, Matti and Smith(1993).
[2] Source: Iowa Department of Education (1990).
[3] Source: College Entrance Examination Board (1990).

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