HIGH SCHOOL SCIENCE ATTITUDES AND ACHIEVEMENT: A LONGITUDINAL STUDY USING ROLE MODELS

Elizabeth Dunkman Riesz, Ph.D.,* and Sandra L. Stephen, Ph.D.+

* The University of Iowa. Iowa City, Iowa
+Cedar Rapids Community School District, Cedar Rapids, Iowa

I. IDENTIFYING THE NEED

In 1989, knowing of the national studies that revealed fewer female and minority students enrolling in and completing upper level physical science courses [1, 2, 3, 4, 5] the Department of Research and Evaluation of the Cedar Rapids (Iowa) Community School District sought and received funding from the FINE (First in the Nation in Education) Educational Research Foundation to examine gender patterns in course enrollment and completion in these upper level science courses. The initial study asked the following question: At graduation, is there a relationship between gender and the completion of upper level physical science courses? The results of this study indicated discrepancies between females' and males' completion of upper level courses [6]. A second study found gender discrepancies among all students enrolled in upper level science courses, not just seniors.

II. PROJECT OVERVIEW

As a result of these findings, the school district began a longitudinal research and intervention project. The purpose of the project was to reduce the discrepancies in science credits earned by females and males in a class of students who would graduate from a district high school in 1995. In 1991-92, the Cedar Rapids Community School District population was 17,049, with 1,492 students enrolled in the project high school. The Target Class in ninth grade consisted of 348 students, with 49.2% female and 50.8% male. The proportion of minority students was 16.4%.

Research activities involved the following: 1) 1991-92: monitoring Target Class (Class of 1995) students' science course enrollment and completion in each of the three trimesters and assessing students' attitudes toward science in February of their ninth grade year; 2) 1992-93: monitoring science course enrollment and completion in the tenth grade year; 3) 1993-94: no research; 4) 1994-95: monitoring science course work, re-administration and analysis of the science attitude survey in the fall of the twelfth grade year; and 4) 1995-

96: analysis of total science course credits earned at graduation by a Baseline Class of 1991 and by the Target Class of 1995. The results of the ninth grade 1991-92 attitude study can be found in [7]. The results of the 1995-96 studies are presented in [8].

The project intervention strategy was based on the theoretical and empirical work of Jacquelynne Eccles and her colleagues which examines social influences that affect student attitudes toward academic decisions [9, 10]. In Eccles' model, student perceptions of the value of the task and student expectations for success in that domain are linked to subsequent course taking. Task value includes: 1) attainment value; 2) utility value; 3) intrinsic value and 4) cost to accomplish the task. Intervention with role models was based on the assumption that if students, especially females, could be exposed to successful female scientists and engineers, they would recognize the career relevance (utility value) of concepts in science classes, become aware of the satisfactions (intrinsic value) associated with such careers, and realize the relatively high salaries and status (attainment value) associated with the careers. Thus, these rewards could be seen as off-setting the costs in persistence and effort needed to complete the requisite courses. Similarly, seeing successful women would emphasize to students that women can expect to achieve success in these fields. Preliminary evidence had been reported that role models are an effective strategy in influencing student attitudes toward science [11].

External funding supported the role model intervention activities described below. The funds paid for a quarter time person to recruit, screen, schedule and evaluate the role models, and for a $50.00 honorarium and travel for the visitors. Role model intervention was funded by The General Mills Foundation when the Target Class was in grades 10 and 11 ($12,000 and $5,000). A grant from The Dwight D. Eisenhower Mathematics and Science Education Act funded a partnership between the University of Iowa Department of Pediatrics, Division of Medical Genetics and the school district. These funds provided intervention when the students were in grades 11 and 12, as well as job shadowing by teachers as well as development of laboratory activities for students ($47,866).

III. PROJECT PROCEDURES

The role models were scientists, engineers, physicians or technicians whose work illustrated some of the scientific concepts and processes which the students were currently studying in their science classes. Science-related benefits included: a) helping students further develop concepts they were studying in science, and b) introducing teachers and students to some of the latest advances in science and engineering. Career-related benefits included: a) demonstration of the application of science/math concepts in a specific career; b) student interaction with professionals who had favorable attitudes and experiences with science and math; c) realistic presentation of necessary education and experience prior to and during a career path.

Three critical components contributed to the effective, and relatively trouble-free, implementation of the role model program: 1) **recruitment and screening** of role models with close attention to the "fit" between the role models work and science concepts students were studying; 2) **targeted scheduling** of role models into classrooms to correspond to current course topics through repeated communication with the teachers and the role models; 3) **evaluation** by students, teachers and role models.

Recruitment and screening. Prior to initiating recruitment of role models, the project co-directors closely examined the sequence of course topics and concepts and brainstormed about the types of jobs that might illustrate those concepts. In addition, meetings were held with the high school teachers to solicit their suggestions for professions to be represented, and for information about course concepts they thought could be clarified though a role model presentation.

Initial recruitment of role models occurred through letters of inquiry sent to CEO's of local industry, to human resource managers, and department chairs at local universities and colleges. The letters explained the purpose of the project, the commitment required of a role model (two 40-minute classroom presentations in one half day in a high school) and requested that the recipient return a nomination form with names of scientists or engineers who would relate well to high school students. The letter indicated that women and minority professionals were a high priority for the project. Subsequently, letters of inquiry were sent to the nominees explaining the project's purpose and outlining the topics to be addressed in classrooms. A response form provided space for a description of the role model's background and work responsibilities.

The co-directors, either together or individually, interviewed each potential role model. The science program facilitator was particularly valuable in the interviews, since the science concepts were often complex and the match between the role model's work and the course outlines needed careful analysis. The two co-directors developed a shared perception of the qualities needed in a role model in order for the visitor to be successful in relating to high school students.

Targeted scheduling. Involvement of teachers in the selection and scheduling of role models was insured by: 1) offering them a list of potential visitors from which to choose, and 2) by requiring that they give a time "window" in which the role would fit well into the course sequence. Given that window, the role model then selected a convenient time. Confirmation letters were sent to role models and teachers. Teachers were asked to contact the role model two weeks before the visit to describe to describe current class work. A co-director followed up with the role model to answer any questions.

Role models extended concepts and demonstrated skills introduced in the high school curriculum. For example: a research pharmacologist visited chemistry classes to demonstrate the use of thin layer chromatography in designing organic molecules; a food science chemist met with biology students to demonstrate the use of spectrophotometry protein testing when protein structure was under investigation; a research biochemist met with an Advanced Placement Biology class to examine changes in cell activity as measured by calcium florescence; a medical geneticist met with heredity and development classes to discuss genetic mapping techniques used to search for muscular dystrophy; an electrical engineer met with physics classes to examine the problem solving process used in delivering clean, reliable power; a research computer engineer illustrated to calculus classes the use of fractal dimension algorithms in medical imaging; a research audiologist demonstrated to physics students the use of audiometry and tympanometry in diagnosing hearing disorders; and an architect illustrated the use of geometric figures in architectural design to geometry students.

Evaluation. Students and teachers completed evaluation forms for each role model visit. Student response sheets were electronically scored and the data were summarized for each class, both by total class and by gender. Role models also evaluated their visits to each class. Teacher and role model forms were tallied by hand.

IV. RESULTS

Science Credits Accrued by Males vs. Females in 1991 and 1995

In the Baseline Class of 1991, significantly more males than females earned two years of science credit and four or more years of science credit. Significantly more females than males earned greater than two but less than three years of science credit. In the Target Class of 1995, there were no statistically significant differences between the amount of science credit accrued by males and females in any of the credit ranges.

Science Credits Accrued by Females in 1991 vs. 1995 and Males in 1991 vs. 1995

The proportion of females accruing less than two years of science credit was significantly greater in the Baseline Class of 1991 than in the Target Class of 1995. The proportion of females in the Baseline Class was also significantly greater than in the Target Class in the credit categories of greater than two years but less than three years and greater than three years but less than four years of science credit. However, the proportion of females accruing four or more years of science credit was significantly greater in the Target Class of 1995 than in the Baseline Class of 1991.

Similarly the proportion of males earning two years of science credit and those earning greater than three but less than four years of credit was significantly larger in the Baseline Class than in the Target Class. The proportion of males earning three years of science credit and the proportion earning four years of credit was significantly larger in the Target Class than in the Baseline Class.

Generally, in the Target Class with role model intervention, a larger proportion of students (both male and female) earned more science credit in credit ranges greater than the two years required for graduation, than did the Baseline Class, without role model intervention and for whom the graduation requirement was the same.

Attitudes Toward Science, 1991 vs. 1995

On some of the dimensions of the science attitude survey, encouraging changes were apparent in the survey of the twelfth grade students, as compared to the survey results when they were in ninth grade. These positive changes may have resulted in persistence in science course-taking. For example, as ninth graders, females had rated their ability in science, compared with other subjects, statistically significantly lower than had males. By contrast, as seniors there was no statistically significant difference in male/female ratings of ability in science. Also, there were no statistically significant differences in the male/female level of agreement with the statement: "It is possible for women to raise a family and have a career in science and engineering." When the students were in ninth grade, females had agreed more strongly with this statement than had males and the difference was significant.

Other results existed that might lead males and females to continue in discrepant patterns in future science course enrollment and completion. Females agreed less strongly than did males about the degree to which they liked science, in comparison with other subjects, and this difference was statistically significant. Senior females, as they had in ninth grade, rated the amount of effort required in science and in math to be greater than did males, and in both years the differences were statistically significant. A detailed description of the results can be found in Riesz, McNabb and Stephen, 1997.

V. CONCLUSION

We could not demonstrate a statistically significant relationship between the role model experience and high levels of course taking. Several factors contributed to the percentage of variance in science credits that could be explained. For females, in addition to ability, two variables that contributed significantly to the variance in science credits earned were perceived utility of science (+10%) and liking science (+2%). One might conjecture that the close relationship between the role models' careers and the high school science class work enabled the students to make a link between high school studies and possible careers. In addition, the role models, by emphasizing that they were not always at the top of their class, and that they took one step at a time and achieved their goal, may have influenced the girls' expectations that women can be successful in science.

In carrying out the intervention component of the project, the following procedures facilitated crisis-free programming: 1) thorough screening of role models by nomination and face to face interviews; 2) provision of a clear outline for the role model to follow in developing a presentation; 3) for both teachers and role models, written confirmation of scheduled time and place for presentation and follow-up well in advance of the visit; 4) involvement of teachers in selecting and scheduling visitors for their classrooms; 5) observation of most role models on their first visit; 6) evaluation by teachers, students and role models; 6) presence of the teacher in the classroom during the presentation.

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