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ABSTRACT

Described is a mathematics-science intervention program for precollege minority students, specifically Chicanos and American Indians. The program is based on the experiences of intervention programs designed to increase the participation of non-minority underrepresented groups in mathematics related careers. It is proposed that in order to maximize the effectiveness of the intervention program activities aimed at impacting teachers, counselors, parents, students, and the school, curriculum should be undertaken on a sustained basis for a long period of time. The involvement of the local community and industry is a necessary ingredient for increasing the effectiveness of these efforts. Also recommended is the inclusion of a sound evaluation program in order to systematically identify the successful activities which can or cannot be duplicated in other geographical localities. (Author/PB)

Suggestions for Increasing the Participation of Minorities in Scientific Research

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Abstract

This article suggests a mathematics/science intervention program for pre-college minority students (Chicanos and American Indians). The suggestion is based on the experiences of intervention programs designed to increase the participation of non-minority underrepresented groups in mathematics related careers. It is proposed that in order to maximize the effectiveness of the intervention program activities aimed at impacting teachers, counselors, parents, students, and the school curriculum should be undertaken on a sustained basis for a long period of time. The involvement of the local community and industry is a necessary ingredient for increasing the effectivity of these efforts. Also recommended is the inclusion of a sound evaluation program in order to systematically identify the successful activities which can or cannot be duplicated in other geographical localities.

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Introduction

Survey studies sponsored by the National Science Foundation (1977, 1980(a), and 1980(b)) and the National Academy of Sciences (1978, 1979, and 1980) have amply documented the underrepresentation of minorities and women in science careers. These findings prompted studies investigating the reasons for this underrepresentation. Perhaps due to questions of race and class, the situation of white women has received heretofore more attention than that of minorities of both sexes (white middle and upper-class researchers focus their attention on white middle and upper-class students at the exclusion of minority students of any economic class). A result of this pattern has been the undertaking of more research projects and intervention programs addressing issues concerning the pursuit of mathematics related careers by women (Blum and Givant, 1980; Parsons, 1980; Casserly 1975 and 1979; Stallings, 1979; Elias, 1980; Weiss, Place, and Conway, 1978; Stroup and Jasnoski, 1975; Fuchs, Weissbrod and Yates, 1978; Bennett, 1976; and Sullivan and Skanes, 1974) than studies investigating the pursuit of similar careers by minorities (MacCorquodale 1980(a) and 1980(b); and Stallings, 1980).

However unexplored the area of minorities in science related careers may be, some of the results from studies with white women can be extrapolated and serve as the basis for conjectures pertaining to minorities of both sexes. There is room to learn from the experiences of these efforts even though they have excluded minorities.

For instance, some intervention programs involving white women have revealed that one time shot conferences or short term activities are virtually ineffective in producing long term results. Also, and more important, the collective experiences of the different intervention programs suggest that a multi-pronged approach is more effective than a uni-pronged one. Thus, it seems unrealistic to expect that one shot conferences, short term activities, and uni-pronged approaches can be effective and produce long lasting effects for minorities.

The purpose of this paper is to suggest an intervention program for minorities aimed at increasing their participation in science related careers in general, and in biomedical scientific research in particular. The suggestion is grounded on findings from the literature describing empirical research studies that investigate the variables affecting the enrollment of women in mathematics courses, and intervention programs designed to increase the participation of women in mathematics related careers.

Background

Since mathematics is ubiquitous in scientific research, a strong preparation in pre-college mathematics is a necessary prerequisite to the pursuit of science related fields at the university or college level. In fact, the pre-college science major includes more courses in mathematics than in any other single science field. Thus, a look at enrollment patterns in mathematics courses of underrepresented groups at the high school level is a natural first step in explicating their representation in science fields at the professional level. It is at this point of the education continuum that most studies on women in mathematics related fields have focused their attention. The results are far from uniform in pinpointing the most determining variables influencing the enrollment of women in mathematics courses.

The studies collectively indicate that there are internal variables (also called affective variables which include such things as attitudes, beliefs and the like) and external variables (which include curriculum, teachers, counselors, parents, and peers) affecting the student's selection of mathematics or science majors in high school. It is commonly agreed that changes in the external variables induce changes in the internal variables but the extent to which each of the external variables individually contributes to the observed changes has been difficult to determine. Consequently, it seems reasonable to suggest that in order to increase the possibilities of achieving the desired changes in the internal variables one must operate simultaneously on all the external variables outlined here.

Let us take a look at the related literature to illustrate better these points and we will intersperse comments regarding activities that should be included in the suggested intervention program.

Affective Variables

There is evidence suggesting that affective variables related to the enjoyment of mathematics are critical in course taking behavior and achievement (Stroup and Jasnoski, 1975; and Fuchs, Weissbrod and Yates, 1978). However, enjoyment of mathematics is not the only variable involved in course taking behavior and achievement; it has been found that parents' believs about their child's ability does predict the child's course taking behavior (Parsons, 1980). And, the availability of accelerated mathematics or science programs in high school has been shown to be related to mathematics achievement. Improvements in mathematics achievement, however, does not necessarily result in more favorable attitudes toward mathematics (Bennett, 1976; Sullivan and Skanes, 1974). On the other hand, perceived usefulness of mathematics to future career plans or rewards has been found to predict change in desires to participate in mathematics related courses at the junior high school level. In this vein, MacCorquodale (1980(a)) reports that Chicanos tend to expend more effort than other groups when school is seen as linked to their future jobs. However, in many instances, current or past rewards seem to have more influence on academic course taking behavior of students in general than anticipated or future rewards, i.e., concrete rewards are oftentimes more influential than abstract ones.

Possible ways of making abstract rewards seem more concrete are the role playing of anticipated or future consequences, and engaging the student in "hands-on" activities (other potentially effective ways are discussed in the section Peers below).

However, for these strategies to be more effective, intervention strategies impacting key agents in the schooling process, such as teachers and counselors must be undertaken.

Counselors and Teachers

Counselors and teachers are the school personnel with whom students interact most frequently. Although counselors do have an influence on students, it is widely recognized that teachers are frequently more influential due to their more intensive contact with students. This is partially explained by the fact that in most schools counselors have a heavier student load than teachers.

The career counselors, however, remain an important source of career information for many students and they should not be neglected by intervention programs. MacCorquodale (1980(a)) has documented the need for Chicano students wishing to study science to be counseled about the necessity of taking more mathematics and science courses beyond the minimum required for graduation. The career counselors can undoubtedly provide this much needed information. Information on employment opportunities in mathematics related fields can also be conveyed to students via career counselors. Above all, the involvement of counselors in mathematics and science intervention projects must be on a sustained basis throughout the duration of the projects through periodic in-service workshops or accredited summer sessions. In addition to better career counseling, students also need better teaching.

One way in which intervention programs can assist in improving the mathematics and science preparation of minority students is by enhancing the academic skills and instructional approaches of teachers servicing these students. Several potentially efficient programmatic activities come to mind. One is to initiate mathematics or science in-service workshops or courses which are integrated into the standard staff development programs rather than "add-ons" or elective. Another alternative is for these workshops or courses to last for an entire academic year. The content of these in-service activities can include statistics, computer science and technology, problem solving methods, the use of calculators in the classroom, teaching techniques, affording to mathematics and science teachers skills and behaviors conducive to encouraging their students to explore different solutions to problems, and the history of the development of mathematics and science.

The purpose for including topics in the history of mathematics and science is to enable teachers to inform students about the dynamic social and human elements that have contributed to the development of these disciplines, and thus remove the notion that mathematics and science are static subjects.

The aim for including problem solving methods, and encouraging students to explore different solutions to problems is twofold. One is to get students to realize that the solutions to problems illustrated by teachers and textbooks are not the only possible ones, thereby promoting creativity. The other aim is to expose teachers to a variety of problem solving methods with the hope that they will, in turn, instruct students in this important intellectual skill so necessary for scientific research.

An alternative to these year long workshops or courses is to initiate summer institutes essentially covering the same content areas outlined above. The summer institutes, however, will probably have to run for several consecutive years, say three or four, involving the same teachers in order to increase the chances of achieving the desired results. One time shots will probably not be effective.

Equally important, although more difficult to accomplish, is to promote positive teacher attitudes and practices toward minority students. Jackson and Cosca (1974) found that teachers significantly favor Anglos over Chicano pupils in teacher-student interactions such as teacher praise, acceptance or use of students' ideas, questioning, giving of positive feedback; non-criticizing teacher talk, and student speaking. Laosa (1977) reviewed the literature on teacher-student classroom interaction and found that teachers are biased against ethnic minority students, students from lower SES backgrounds, low achieving students, and students who do not speak standard English. The possible short and long term negative consequences of such teacher behavior defy quantification, and are undoubtedly counter productive to the advancement of Chicanos, American Indians, and blacks in science. The cooperation of local school officials is needed in this area.

The School Curriculum

Recent information concerning the shortage of trained scientists in the United States has compelled interested individuals to look at the pre-college mathematics and science curriculum. It has become evident that the prevalent curricula throughout the nation places too much emphasis on basic computational skills at the expense of more complex skills such as reasoning and problem solving. Although it is difficult for intervention programs to institute structural changes leading to a more balanced mathematics and science curriculum, it is quite possible for these programs to advocate curriculum reforms leading to the inclusion of more problem solving activities and the creation of advanced courses in these subject areas.

This modest goal can be facilitated through the involvement of public school teachers and university mathematics and science professors in designing and developing supplementary curriculum materials. These materials can be used for enrichment activities in conjunction with the regular curriculum. It is more desirable, of course, to integrate these materials into the regular school curriculum.

In short, the pre-college mathematics and science curriculum needs to include more problem solving activities, and more advanced or accelerated courses. Intervention programs for minority students can play the dual role of advocates and facilitators of curriculum reforms stimulating the improvement of the mathematics and science educational experience of the target populations.

Intervention programs can also play a role in contributing toward the systematic identification and education of minority gifted students. This particular-student population is presently being neglected by the schools and by programs for the gifted which focus their attention on white students. Curriculum materials and curriculum programs are badly needed for this valuable national human resource.

Parents

Parents can play an important role in students' career decisions and their inclusion in intervention programs is of utmost importance. Studies have shown that parents can be so influential on their children's choices that a mere belief on the children's ability can predict course taking behavior (Parsons, 1980). With respect to attitudes, Armstrong (1979) found that parental attitudes toward mathematics and science are potent factors in their children's participation in mathematics or science related activities.

It is quite possible that the impact of parental beliefs and attitudes on children can be augmented when parents are in a position to provide factual information regarding course requirements for, and opportunities in, science careers. Chicano parents in particular lack this kind of information (MacCorquodale 1980(a)) and thus aggravating the condition of relative disadvantage of their children. Mathematics and science intervention programs can easily alleviate this situation by providing the indicated information and incorporating the parents in program activities. For instance, parents can be included in field trips to local scientific laboratories and industry accompanying teachers and students, and evening programs for parents could be organized.

It is also possible that through parents involvement in intervention programs the local schools, local industry and the local community can be more predisposed to participate and support the program. Stallings (1980) reports that the highest enrollment in mathematics courses occurred in a minority urban school with active community and business support. Parent and community support can also be instrumental in achieving institutionalization of curriculum reforms and intervention programs in the local schools and thereby increasing the potential impact of programs.

Empirical investigations reveal that when parents are approached about science and mathematics career information for short periods of time the impact on their children is minimal. Thus implying that long sustained efforts with parents can be more fruitful.

Peers

There are many instances when the advise and influence of parents, teachers and counselors have to compete with the influences of a student's peer group. Peers appear to be of great influence in course taking behavior of white women and it is plausible that this is also the case with minority students. This possibility accentuates the need for science intervention programs to include activities involving in-and-out-of-school peer groups. Activities informing and educating the student and his peers about the importance of technology and science in the everyday world, and the academic requirements necessary to pursue mathematics related careers are essential.

These objectives can be achieved by means of films, conferences, speakers, summer and year long internships for high school and college undergraduates in local industries, field trips to scientific and industrial work places, curricula and extra curricula offerings, local and regional student science fairs and competitions, hands-on experiences, group projects, and student science and math clubs. The likelihood of attaining the desired impact of these activities is increased when undertaken on a long sustained basis, and maximized if they are institutionalized.

It has been the experience of educational reform programs in other countries that their impact is increased when they are accompanied by social and economic reforms. The prospect of good paying jobs for those minority students who pursue mathematics and science related professions can partially fulfill this role. The prospect of good paying jobs as a reward is a bit abstract, but summer and year-long internships in local industries can assist in making the rewards seem more concrete.

Another way of making abstract rewards seem more concrete for some students is to involve them as peer-tutors on a paid basis. This could accomplish at least two additional things: the peer-tutors will have a chance to teach others what they know, and their motivation for continuing to study mathematics and science might increase.

Discussion

In the previous pages, we discussed the internal (affective) and external (teachers, counselors, curriculum, parents, and peers) variables which have been identified as important in mathematics intervention programs affecting the participation of white women in careers which use mathematics. It was assumed that these same variables are also important for similar programs with minorities. The various program activities mentioned are only suggestions because the specific implementation strategies have to vary according to the particular group being targeted and the local or regional socio-economic circumstances.

On the whole, the internal variables are more elusive than the external ones and the best anyone can hope for is that by operating on the latter, positive changes will occur in the former. The next step in such a process is to identify clearly which external variable(s) is (are) more important in inducing positive attitudes. Not an easy task. This role is best fulfilled by an evaluation component incorporated in the intervention program.

The fact that no two local or regional communities are alike, due to their own particular socio-economic and political dynamics, makes it virtually impossible to superimpose similar preconceived experimental designs on several communities. The local or regional dynamics determine the kind of intervention activities that can be effective. Also, it is frequently the case that when changes in the internal variables are observed, e.g., attitudes toward the biomedical sciences change positively, the cause, meaning or consequences of the changes are oftentimes vague or unclear. Consequently, rigorous evaluation procedures are necessary to identify successful activities and their respective implementation procedures.

The task to trace the cause of changes in the internal variables in a complex human environment, such as the one suggested by the external variables above, emphasizes the need for sound evaluation procedures which include qualitative and quantitative techniques. The eventual goal is to ascertain systematically those activities, implementation strategies, and their corresponding degree of success, that can or cannot be replicated in different communities. To put it differently, the end result of the program evaluation should be to indicate the what, the how, and the patterns of success of the various intervention program activities.

The list of references at the end of this article includes descriptions of mathematics and science intervention programs for women that might be useful in designing similar efforts for minorities.

Summary

The literature on women in mathematics related careers indicates that it is easier to affect the external variables (curriculum, teachers, counselors, parents, and peers) than to affect the internal variables (attitudes) when the goal is to increase student participation in mathematics related fields. It is also evident that intervention programs designed to affect the external variables are more effective when they are sustained for a long period of time, become institutionalized, and all of the external variables are operated on simultaneously, e.g., the schools, the local or regional community, and local and regional industries must work cooperatively in the task to increase the representation of minorities in science related careers.

The central goals of any mathematics and science intervention program should be the development of strong basic skills, problem solving abilities and approaches in the target minority population in order to equip such individuals with the fundamentals for scientific research.

It was also pointed out that a rigorous program evaluation or research component is necessary in intervention programs so that effective and replicable activities and implementation strategies can be identified.

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