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Developing Math and Science Skills Among Disadvantaged Youth: A Review of the Upward Bound Precollege Math/Science Centers

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This review of centers funded under the Upward Bound Math/Science program reflects the contributions of many individuals. Dr. David Goodwin in the Planning and Evaluation Service of the U.S. Department of Education first conceptualized a study of the math/science centers (MSCs) that could amplify and inform the Department's evaluation of the regular Upward Bound program. His dedicated support was critical to making the study a reality. The researchers who conducted the case studies on which this report is largely based were instrumental to the success of this study, particularly in their ability to capture a variety of perspectives on center operations. The team included Mary Moore, David Myers, Susan Reidinger, and Jennifer King-Rice. Also instrumental to the study were Jill Corcoran, who reviewed the literature and analyzed other precollege programs, and Robert Howard, who collected background information on 1995 math/science grantees and analyzed 1993-94 Annual Performance Reports from grantees. Tim Silva made key contributions to interpretations of the study's findings and the contents of this report. Darnecia Morris tirelessly produced and assembled the report.

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BACKGROUND

National statistics show that while the gap has narrowed from the 1970s, economically disadvantaged students today remain considerably behind their more advantaged peers in terms of math and science achievement. For example, recent data show that black and Hispanic students start high school with math and science achievement levels almost two years behind those of their white peers (U.S. Department of Education 1996, 1995b). Compared with white high school graduates, far lower percentages of black and Hispanic graduates complete math and science courses such as geometry, chemistry, and physics. And low-income and minority students are substantially underrepresented among many math and science majors in college (U.S. Department of Education 1994).

To help close these gaps, in 1990 the U.S. Department of Education (ED) established a math/science initiative within Upward Bound, a federal grant program supporting a variety of services to provide low-income and potential first-generation-college students who are in high school with the academic and related skills needed for college success. While "regular" Upward Bound projects are not expected to emphasize particular postsecondary or career paths, the specific objective of math/science centers (MSCs) is to prepare participating students for postsecondary programs that lead to careers in the fields of math and science (U.S. Department of Education 1995).

ED currently funds 81 MSCs across the nation, typically located at colleges or universities, with grants totaling about $20 million. These centers must provide students with an intensive six-week summer program of math and science instruction and related activities, including hands-on experience in laboratories, computer facilities, and field sites; exposure to mathematicians and scientists engaged in research or applied science; and interaction with counselors and tutors who are undergraduate and graduate students in math and science fields. MSCs must also offer instruction in other subjects such as composition, literature, and foreign language, and are expected to monitor participating students' educational progress during the subsequent school year, arranging extra academic assistance when necessary.

OVERVIEW OF MAJOR FINDINGS

MSCs stand out as unique programs in several aspects. Compared with regular Upward Bound projects, MSCs typically enroll fewer students, maintain lower student-to-staff ratios, and spend more dollars per student; enroll slightly higher achieving students who express stronger interest in math and science related careers; and serve students from broader geographical areas during the summer, but deliver fewer services during the school year. In addition, compared with other precollege math/science programs, MSCs target somewhat older students and offer longer residential summer programs.

In general, MSCs appear to offer high quality learning opportunities. Centers devote a substantial amount of time to academic pursuits, and the instructional techniques employed reflect practices

approved of by pedagogical experts. MSCs structure their curricula in two different ways: some use an interdisciplinary approach, integrating multiple subjects (for example, teaching math concepts in science classes), while others use a discrete-subject approach similar to the typical college-prep curriculum in high schools. Centers also require that students adhere to fairly strict behavioral standards. Most staff are secondary school teachers or graduate students; postsecondary faculty rarely serve as center instructors. However, MSCs often have difficulty arranging formal mentoring opportunities for participants due to professionals in the field being difficult to recruit and having limited time to commit to these roles.

MSCs have fairly limited interaction with other programs and institutions. Centers typically operate separately from regular Upward Bound projects and other precollege programs, even those located on the same campus; the interaction that does occur tends to revolve around activities such as student recruitment. Centers also provide relatively few opportunities for parental involvement and typically have a very limited presence in participants' high schools.

MAJOR FINDINGS: A CLOSER LOOK

MSCs Are Notably Different from Other Precollege Programs

MSCs differ markedly from regular Upward Bound projects on several dimensions.

- ***Greater Intensity of Services and Resources.*** The average enrollment at MSCs is 46 students, compared with 75 at regular projects; the average cost per student is $5,116, compared with $3,839; the average student-to-staff ratio in the summer component of MSCs is 2.6:1, compared with 5.1:1; and MSCs are more likely to be hosted by four-year colleges. These differences can be explained in part by perceptions that intensive interaction between staff and students is necessary to provide a high quality experience for participants, and in part by MSCs' decisions to focus on specific staff-intensive activities such as research projects and field work.

- ***Regional Outreach.*** While most regular Upward Bound projects serve primarily students from the surrounding community, MSCs are much more likely to follow a regional service delivery approach, recruiting students from a wider geographic area. Twelve of the 14 case-study centers were regionally oriented, although the size of their targeted areas varied.

- ***More Select Students.*** MSC students tend to be a more select group than regular Upward Bound participants. In particular, MSCs are more likely than regular projects to require that students (1) demonstrate an interest in math or science and (2) have a minimum grade point average (typically C or better). In addition, MSC staff describe their students as performing somewhat better in school than regular Upward Bound participants. Nonetheless, MSC staff say that many center students still need the kind of academic and other assistance that the centers offer in order to enable them to succeed in college, especially compared with their economically better-off peers. We uncovered no unique differences in the high schools targeted by MSCs and regular Upward Bound.

Moreover, students in MSCs indicated no special lab courses or special science tracks in which their high school had placed them.

- ***Summer Program Focus***. Compared with regular Upward Bound projects, MSCs focus their resources in a way that provides a more intensive program during the summer, especially viewed in terms of the number of staff available to students. In contrast, however, MSCs deliver fewer services during the school year; on average, they devote about 75 percent of their annual budgets to the summer component, compared with 52 percent among regular projects.

Some of these differences make it difficult for many MSCs to report the performance data ED requires of all Upward Bound projects. In particular, the limited contact most MSCs have with students drawn from a wide area make it hard to collect complete information on the high school and college outcomes of students after they complete the summer session. Well under half of all MSCs provided this information in their 1993-94 performance reports.

MSCs also differ from other precollege math/science programs for disadvantaged youths in several respects. Most notably, compared with 28 other programs reviewed, MSCs stand apart by their focus on serving high school students and in offering a summer program that usually combines two features: it is residential and lasts six weeks. Based on reported annual estimates, MSCs tend to spend more per student than most other precollege efforts focused on math and science.

MSCs Provide High Quality Learning Opportunities

The case-study centers appeared generally to provide high quality learning opportunities. During a typical six-week session, students devote at least half of their awake hours to academics, either in classrooms, laboratories, or study halls. By summer's end, most students will have logged in almost 200 hours in academic coursework and study. Furthermore, classroom observations conducted during site visits revealed that math and science instructors were using the kinds of effective instructional strategies recommended by groups such as the National Academy of Science's National Research Council and the National Council of Teachers of Mathematics. For example, courses involved a good deal of hands-on activities, lab work, field work, and active teaching--a practice in which instructors engage students in a two-way dialog, rather than simply lecturing to them.

About two-thirds of the case-study centers followed an interdisciplinary approach in their curricula, attempting to provide instruction that integrates concepts from multiple subjects. For example, one center focused most instruction around the theme of marine science, simultaneously applying concepts from math, science, and other subjects. The remaining one-third of centers taught subjects such as math, science, and composition separately, as is traditionally done in high schools. In theory, both approaches may be equally effective and appealing to students.

MSCs adopt strict standards for student behavior that help keep the focus on academic work. For example, students must adhere to rules governing their dress, language use, class attendance, and academic effort. Some of these standards, in fact, are more rigorous than those typically applied in the regular Upward Bound projects operating on the same campuses. Inappropriate behavior or

insufficient commitment to coursework can result in a range of sanctions, from formal warnings to dismissal from the program.

Most instructors at the case-study MSCs worked as high school math or science teachers during the school year. They often cited the relatively small class sizes as an especially attractive feature of teaching at the centers. Most tutors were undergraduate or graduate students from math or science fields. However, MSCs rarely succeeded in drawing instructors from the ranks of tenure-track college faculty, due in part to their higher salaries and a desire to devote their summers to their own research. Difficulty in attracting college faculty--as well as professionals working in applied fields in the nearby community--makes it hard for many centers to arrange structured, meaningful mentoring opportunities for their students.

MSCs Have Limited Interactions With Other Programs and Institutions

MSCs' interactions with other programs and institutions are fairly limited, revolving mainly around student recruitment and related activities. Centers typically operate independently of regular Upward Bound projects--even when those programs are located on the same campus, which is a very common situation. For example, MSC students and those in regular projects might have some joint informal activities, such as dining or recreation, but rarely do they share the same dormitories or take any classes together. This degree of separation between MSCs and regular projects may have various explanations, including (1) each staff's need to maintain control over their own participants, (2) an expectation that the two programs should offer students distinct experiences, and (3) a perception that the MSC students need a more challenging academic program than many regular projects offer. These same reasons also may help explain why there is little interaction between MSCs and other precollege programs on the same campuses.

Centers' limited interactions with off-campus programs and students' high schools also focus mainly on recruitment and follow-up activities. Two notable exceptions were the locally oriented case-study centers, which dedicated staff to maintain a presence year-round on nearby high school campuses. Finally, most MSCs offer relatively few formal opportunities for parental involvement, which is somewhat understandable due to the distance of many centers from students' homes.

CONCLUSIONS AND PROGRAM ISSUES

This study, conducted six years after the start of the Upward Bound Math/Science Initiative (UBMSI), provides a good opportunity to consider what lessons can be learned from the centers and to ask questions about their future direction. The major findings from this study are that Upward Bound math/science centers:

(1) differ in important ways from regular Upward Bound projects and other precollege programs,
(2) appear to offer high quality learning experiences, and
(3) interact to a limited extent with outside programs and entities.

The case studies and other analyses conducted, however, cannot address the important question of how effective MSCs are in accomplishing their primary objective--to prepare disadvantaged students for college studies leading to math and science related careers. A study directly addressing the impact of program participation on students' academic and career pursuits--in math and science as well as more broadly defined--would not only suggest whether the money invested in the UBMSI has been well spent, but could also produce findings that would inform how other precollege programs might be structured and operated.

This study also brought to light certain program management issues that ED may want to address.

- ***Should MSC enrollments be enlarged?*** On one hand, center enrollments are below the 50-75 student target levels set by ED. Since MSCs typically had more applicants than they accepted, it can be argued that the interesting and challenging activities centers offer could reach a greater number of disadvantaged students. But on the other hand, staff cite low student-to-staff ratios as one of the most attractive and important conditions within the centers. The low student-to-staff ratios permit instructors to work closely with students both on problem-solving strategies and in lab and field settings. Furthermore, any significant increase in the number of students served by centers would require some increase in funds going to each center--to address residential costs and other resources necessitated by their presence. How specific student-to-staff ratios influence centers' effectiveness is a question that cannot readily be tested, however, because centers vary so little in this feature.

- ***Should MSCs be required to offer foreign language instruction?*** Center staff are struggling with how to include foreign language courses in their curricula. Some suggest that the requirement detracts from the centers' primary mission, to provide intensive instruction in math and science. Eliminating the foreign language requirement, however, will require a change in the federal government's approach to MSCs. Under current ED interpretations, MSCs must conform with the legislative requirements governing Upward Bound in general, which obligate all projects to offer a foreign language.

- ***Should MSCs be held to all of the same performance reporting standards as regular Upward Bound projects?*** Because most centers have a regional orientation and most students participate in center activities for a limited time, center staff often have difficulty tracking students' academic progress through high school and into college. Therefore, a different set of outcome data requirements may be more appropriate.

- ***What are the potential benefits of increased interaction and information sharing between MSCs and other precollege programs, and how might such efforts be encouraged?*** The isolation of most MSCs from other precollege programs, particularly regular Upward Bound projects at the same host institution, may mean that counterproductive messages are conveyed to students in the other programs about their skills and academic potential. It also suggests that information on effective practices is not being routinely exchanged by programs--to the potential detriment of the disadvantaged students these programs are trying to help. One way ED might encourage MSCs to share their curricula and other ideas would be to take dissemination activities into account when renewing MSC grants.

RESEARCH QUESTIONS AND METHODS

This report examines the unique aspects of MSCs by providing descriptive information on service delivery methods, student recruitment, course offerings, activities and support services, staffing, parental involvement, and relationships to other entities and programs, including participants' high schools. The following questions are addressed:

- To what extent do MSCs' programs differ from programs offered by regular Upward Bound grantees? How do MSCs compare with other non-Upward Bound programs that focus on math and science?

- How do MSC programs compare with currently accepted views of best practice in math and science instruction?

- How do MSCs interact with regular Upward Bound projects and other precollege initiatives to help disadvantaged students prepare for math and science related careers?

To gather information on MSC operations, Mathematica Policy Research, Inc. (MPR) conducted in-depth case studies at a representative sample of 14 centers. The site visits included interviews with staff, observations of classroom instruction, reviews of various documents, and focus group discussions with students. To complete the study, MPR also reviewed (1) trends in math and science performance of disadvantaged groups and information on effective instructional approaches for these groups, (2) 1993-94 performance reports submitted by MSCs to ED, and (3) information on 28 precollege math and/or science programs that focus on disadvantaged youth.

I. INTRODUCTION

The unequal representation of persons from low-income and minority backgrounds in majors and careers in math and science has long aroused federal attention. A recent round of federal interest emerged in the mid 1980s after the issuance of the landmark report, *A Nation At Risk*, by the National Commission on Excellence in Education. This interest was further stimulated in 1989 when the president and the nation's governors joined forces to adopt six national education goals, the fifth of which aimed to make U.S. students first in the world in mathematics and science achievement by the year 2000. Included in the various objectives tied to this goal was a significant increase in "the number of U.S. undergraduate and graduate students, especially women and minorities, who complete degrees in mathematics, science, and engineering...."

One action taken by the U.S. Department of Education (ED) to help meet this goal was the creation of a math/science initiative within the federal Upward Bound grants program. The large majority of Upward Bound grants support multiyear, year-round services to equip low-income and potential first-generation-college students who are in high school with the academic and related skills necessary to enter college. Since 1990, however, the Upward Bound math/science initiative (UBMSI) has funded a limited number of grantees to perform a specialized mission: the establishment of centers "to prepare participating students for postsecondary programs that lead to careers in the fields of math and science" (U.S. Department of Education 1995).[1] Most "regular" Upward Bound projects

[1]In addition to regular and math/science center grants, the Upward Bound program office also awards a small number of grants specifically for assisting veterans. Upward Bound is one of the federal TRIO programs which are authorized by Congress under the Higher Education Act's provisions for Special Programs for Disadvantaged Students. These also include Talent Search, Student Support Services, Educational Opportunity Centers (EOC), Staff Training, and McNair Post-Baccalaureate Achievement.

are not expected to emphasize specific postsecondary or career paths, although they can do so as long as they meet other requirements for regular grants (for example, enrollment levels and provision of both summer and academic year services for students from grades 9 through 12).

A. PURPOSE AND SCOPE OF THIS REPORT

Currently 81 math/science centers (MSCs) across the nation receive grants under the UBMSI. [2] Combined, these grants represent $20 million, or about ten percent of the total funds awarded annually to regular and veterans Upward Bound projects. The MSCs must provide a six-week summer program that simulates college and engages eligible low-income, potential first-generation-college students in an intensive program of math and science instruction and related activities. Furthermore, ED currently expects MSCs to follow and monitor the academic progress of participating students during the subsequent school year and to arrange, when necessary, for extra educational support. Under current rules, the centers may limit students' participation to one summer (with the follow-up year), or they may allow the students to participate for several years throughout high school. The centers also must meet the requirement to offer core subjects that Congress recently mandated for all Upward Bound programs. These core subjects include mathematics through precalculus, laboratory science, foreign language, composition, and literature.

As a first step in examining the unique aspects and effectiveness of MSCs, this report provides descriptive information pertaining to the centers. The report focuses on a variety of program characteristics--the models of service delivery employed by centers, student recruitment, instructional offerings, education related activities and support services for students, center staffing, opportunities for parental involvement, and the centers' relationships to other Upward Bound projects, math/science

[2]Throughout the remainder of this report the terms math/science centers, MSCs, and centers are used interchangeably.

education efforts, and participating students' high schools. The findings presented in this report address the following questions:

- To what extent do MSCs' programs differ from programs offered by regular Upward Bound grantees? How do MSCs compare with other non-Upward Bound precollege programs that focus on math and science?
- How do MSC programs compare with currently accepted views of best practice in math and science instruction?
- How do MSCs interact with regular Upward Bound projects and other precollege initiatives to help disadvantaged students prepare for math and science related careers?

The report draws upon four sources of information: (1) in-person case studies conducted in the summer of 1996 in a representative sample of 14 MSCs;[3] (2) a review of trends in math and science performance among underrepresented groups and effective instructional approaches for these groups; (3) the 1993-1994 annual performance reports MSCs submitted to ED; and (4) a review of 28 precollege math and/or science programs that are not part of Upward Bound and were selected for their focus on disadvantaged youth. Among the four sources, the case studies offer the richest and most direct information about MSCs' operations. The case study visits included interviews with a wide range of staff, class observations of teaching practices, reviews of relevant documents (for example, curriculum guides, course syllabi, the grant proposal, budget, and performance reports), and focus group discussions with students in the programs. Although the sample of 14 centers is too small to generalize with great confidence to the universe of MSCs, it contains sufficient breadth to profile the practices used by MSCs and the issues they confront.

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[3]A stratified random sample was used to identify the 14 MSCs visited in the case studies. The sample was constructed to reflect three broad regions of the country (West, South, Midwest/Northeast), grantees' urban and rural location, and the two-year and four-year nature of the institution hosting the MSCs. (Only two of the 81 centers funded in 1995 had a host other than a two- or four-year college.)

MSCs' impacts on students are not addressed in this report. Unfortunately, reliable data on MSCs' effects on students do not exist. The information presented in this report, however, begins to address the issue by laying a foundation of knowledge upon which approaches to assess the effectiveness of MSCs can be considered.

B. THE ISSUE BEHIND THE CENTERS: CONTINUING GAPS IN THE MATH AND SCIENCE PREPARATION OF DISADVANTAGED YOUTH

A variety of indicators of U.S. math and science performance over the past 15 to 20 years relate a similar story about the educational pipeline that feeds technology-based professional careers. Despite some narrowing, a significant distance still separates the math and science performance of disadvantaged students from that of their peers. In fact, gaps are evident at many stages in the math/science education pipeline from elementary school through graduate study.

Generally speaking, the nation clearly made progress since the 1970s in increasing the math and science performance of under-represented, largely-disadvantaged subgroups.[4] Trend data that describe racial/ethnic groups' performance within the U.S., for example, document significant across the board improvement in minority students' completion of high school math and science courses, scores on standardized assessments of math and science, expectations to complete graduate work, and plans to major in science or math related fields in college. Moreover, minorities have increased their representation among the ranks of those awarded college degrees in science and engineering and those employed in such fields.

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[4]Ideally, socioeconomic measures would be used to compare subgroups. However, for most of the education indicators of interest, few sources of data publish trends by students' socioeconomic status. Because racial/ethnic subgroups in the U.S. share disproportionately in income disparities, indicators based on these subgroups offer a reasonable, albeit imperfect, estimate of economically disadvantaged students' math and science performance over time. Where available, parents' educational status was examined in this review of trends. Little difference emerged for most indicators considered.

Against this backdrop of progress for the numerous groups, the data also reveal that the improvement in the performance of disadvantaged subgroups generally has not occurred at a fast enough pace to remove the previously existing gaps. The following points illustrate why concern remains high about white and minority group differences, particularly in the math and science areas.

- In 1994, only 58 percent of black high school graduates completed geometry, compared with 73 percent of white high school graduates (U.S. Department of Education 1996).

- In the same year, only 13 percent of black and Hispanic graduating seniors had completed the triad of science courses--biology, chemistry, and physics. Twenty-three percent of white graduates completed the science triad (U.S. Department of Education 1996).

- The National Assessment of Educational Progress (NAEP) indicates that racial/ethnic gaps in students' math and science performance are present at age 9, and continue to be present at ages 13 and 17. Notably, in 1992, achievement differences effectively placed black and Hispanic students almost two years behind their white peers in math and science achievement at the onset of high school (U.S. Department of Education 1995b, c).

- The percentage of black and Hispanic college students receiving credit for calculus/advanced math courses in the late 1980s was considerably less than that of white college graduates (10 and 14 percent respectively, compared to 22 percent). College chemistry and physics courses reflect similar patterns. Only 16 percent of blacks and 21 percent of Hispanics earned course credits in chemistry (27 percent of white students earned credits) and only eight percent of blacks and 11 percent of Hispanics completed a physics course (18 percent of white students completed) (U.S. Department of Education 1994).

The above disparities explain why interventions that have the potential to accelerate the pace of math and science improvement for disadvantaged students have interested policy makers. Upward Bound, in particular, has offered an attractive vehicle within which to develop math/science interventions because of the program's explicit purpose of supplementing the academic preparation of low-income, first-generation-college youth in their high school years.

While the trend data cited above suggest the need for interventions such as the UBMSI to help accelerate the pace of improvement, they also illuminate several issues involved in implementing such interventions. For example, is it better to deepen and extend the math and science proficiency of high school students who have demonstrated some proficiency in math and/or science--in other words, those students who are part of the progress made in high school course taking and achievement scores? Or should the UBMSI target the group of students who have little exposure to or have yet to acquire proficiency in high school math and science subjects? The data showing progress and gaps in math and science performance indicate that both types of students are potential candidates for interventions such as the UBMSI. How have federal regulations addressed these and other questions about the design of MSCs?

C. THE FEDERAL MODEL OF MSCs: THE EVOLUTION FROM REGIONAL TO LOCAL CENTERS

Federal policymakers have framed the issue of which students to target for the intensive math and science program primarily in terms of whether to focus on students already participating in Upward Bound or on students outside of Upward Bound. In fact, clarifying the relationship of the MSCs to regular Upward Bound and structuring the MSCs so that they fit within the larger Upward Bound context have been central issues for federal officials. Generally speaking, specific targeting requirements tied to previous course work and students' performance in math and science have been left to the centers to resolve.

1. The Regional, Upward Bound Targeted Model of MSCs

The original model of MSCs adopted by ED called for regional centers that would serve about 50 students from regular Upward Bound projects who had completed ninth grade. Since ED chose not to focus the program on students who had completed the eighth grade, which is the age standard

applicable to regular Upward Bound grantees, MSCs indirectly were guided toward students who having completed ninth grade were likely to have taken a high school science and math course prior to their entrance into the MSC.[5]

Originally, ED officials conceived of the regional centers as supplementing and enriching the programs of regular Upward Bound projects within the TRIO geographic regions.[6] To effect this conception, ED relied on regular projects to identify Upward Bound students who could benefit from the intensified math and science programs of the regional centers. Accordingly, students who were accepted would return to their home Upward Bound projects to continue to participate in the academic year component of regular Upward Bound and any subsequent summer services.

Left unresolved in this regional design were issues of which project paid for transportation costs to the MSCs and how sending projects should report counts of MSC participants in annual performance reports. These reports were a key consideration when regular projects came up for refunding in the next cycle of competitive awards, and often could make the difference in whether a project received a sufficient number of points to maintain its grant.

The concept of a regional center offered several attractive features to UBMSI decision makers. Because the design built upon existing Upward Bound projects, it promised potential efficiencies from regular projects performing the tasks of recruiting and assessing the academic needs of Upward Bound candidates. From a federal grants perspective, the regional model was compatible with the time-frame and amount of funding available for ED's first-year awards. The original grants covered only one year

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[5]The Final Priority governing the initial grants made under the UBMSI indicates that ED planned to separately instruct "sending [Upward Bound] projects...to select students who have completed 9th grade and who are interested in math and science, and who have taken at least one course in math and science at the ninth grade level" (Federal Register, August 7, 1990).

[6]TRIO projects are organized into ten geographic regions, each of which comprises four or more states.

and were pegged at $100,000 per grant. From the perspective of effective practice, the design provided a mechanism for the sustained involvement of students in Upward Bound instructional and support services beyond a single summer. Students' continued involvement in Upward Bound has emerged in evaluation studies as contributing significantly to the regular program's effectiveness (Burkheimer et al. 1979, Moore 1996, Myers 1996).

2. Emergence of Alternatives to the Regional, Upward Bound Targeted Approach

Not surprisingly, ED's model of a math and science center changed considerably as the UBMSI expanded from its initial 30 grants to the current number of 81. Difficulties in recruiting a sufficient number of students from sending projects led some critics to question the feasibility of the regional model. These critics saw major drawbacks in the MSCs' geographic distance from students and the existence of disincentives for regular projects to send youth to the MSCs. By late 1991 ED extended MSC eligibility to students who were not participating in regular Upward Bound. This expanded eligibility, in turn, intensified ED's interest in provisions that would encourage MSCs to offer a more sustained precollege program of assistance for students who had no "home" Upward Bound program. ED's creation of multiyear grants, in theory, helped resolve this concern by enabling MSCs to offer additional summers for returning students. The elimination of requirements for MSCs to recruit within the entire region opened another avenue to ensuring continued support to students during the academic year. In short, ED adopted a policy whereby MSCs could be entirely local.[7] As an additional measure, ED now has begun to require projects to provide for some form of follow-up services for students during the academic year after they have participated in the center's summer program.

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[7]It is not easy for a regional center to shift to a local center and still retain its competitive edge in grant determinations. ED does not permit centers that are seeking to become a local program after having been funded as a regional program to acquire the additional priority points that incumbent projects are entitled to receive during the competition for grants.

The net result of these changes is that MSCs now may use several recruitment channels and may pursue either a regional or locally oriented approach (Figure 1.1). MSCs may recruit students from Upward Bound or the Talent Search programs in a geographic area, and they may draw students directly from high schools and other community programs. To reduce impediments within the regular Upward Bound community, ED also has taken steps to reduce disincentives for regular projects to send students to MSCs. For example, ED now allows both the MSCs and the sending projects to count students in their respective performance reports. Furthermore, in the interests of flexibility and opening recruitment, ED now allows MSCs to accept students who have completed 8th grade. In sum, as far as federal requirements are concerned, MSCs may structure their programs in a manner that best meets their unique challenges in recruiting and providing opportunities for sustained services to students.

D. FEDERAL REQUIREMENTS RELATED TO THE CONTENT OF MSC ASSISTANCE

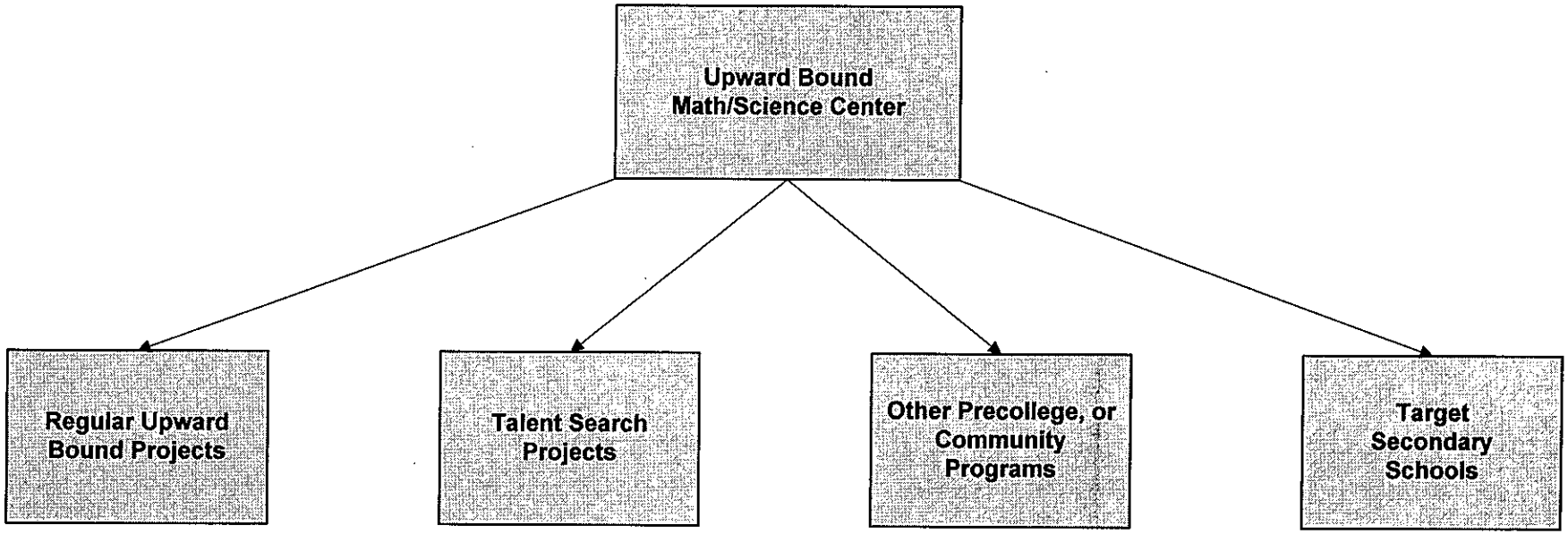
The content of MSC programs, although largely determined by staff in individual MSCs, is subject to certain federal specifications. These specifications convey federal expectations regarding the types of instructional services and activities that define an intensified math and science precollege experience. Because they establish a set of rules that apply broadly to all MSCs, regardless of circumstance, the specifications also present potential difficulties for some centers.

According to ED's published rules, MSCs are obligated to provide the following:

- instruction that includes hands-on experience in laboratories, computer facilities, and at field sites
- opportunities to learn from mathematicians and scientists at the college or engaged in research or applied science in other institutions in the surrounding community
- involvement with tutors and counselors who are graduate and undergraduate math and science majors

FIGURE I.1

STUDENT RECRUITMENT OPTIONS FOR
UPWARD BOUND MATH/SCIENCE CENTERS, 1995



- a six-week summer program consisting of daily course work and activities, and instruction in mathematics through precalculus, laboratory science, foreign language, composition, and literature.

Instruction based on hands-on activities and the inclusion of both mentors and role models from the academic and professional realm have been widely accepted as effective elements in developing math/science skills and interests in youth. Accordingly, MSC staff generally raise few objections to the existence of these requirements although finding available individuals to perform these roles may present them with some challenges. The requirement that calls for a full range of subjects, however, has bothered many operators of MSCs who view it as inappropriate for a program emphasizing two specific disciplines. They particularly take issue with having to offer foreign language when they see the time for concentrated attention to math and science as extremely limited. Offering the list of core subjects has only recently been imposed as an obligation on MSCs; it results from Congress' efforts to ensure the academic thrust of the Upward Bound program. Because the MSCs are embedded within the general Upward Bound legal framework, ED has determined that they must comply with this requirement.

As the federally promulgated model of MSCs has evolved to permit local, multiyear centers, and as broad subject requirements have been imposed on the MSCs, some concerned parties have argued that the distinctive mission of the MSCs has been diluted. These parties predict that MSCs will come to resemble regular Upward Bound projects. This prediction seems even more plausible given recent evidence that indicates a number of regular projects are themselves moving closer to the curricular emphasis of MSCs. Just over one-third of all regular projects now emphasize a math/science orientation that requires students to take reading, writing, algebra I and II, geometry, precalculus or calculus, and three science courses (Moore 1996). How the MSCs structure their programs to offer a unique program is the main theme of the next chapter.

E. ORGANIZATION OF THE REPORT

Each of the subsequent chapters of this report addresses a specific aspect of MSCs. As noted, the next chapter assesses how distinct MSCs are. The third chapter focuses on the quality of the curriculum and instruction provided by MSCs, as measured against currently advanced conceptions of effective practice. The fourth chapter examines MSCs' relationships with regular Upward Bound projects, and other programs and institutions that affect students who are the intended beneficiaries of the math/science initiative. The final chapter presents conclusions based on the findings in preceding chapters, and discusses the implications that flow from these conclusions.

II. HOW UNIQUE ARE MATH/SCIENCE CENTERS?

On several dimensions, Upward Bound math/science centers differ markedly from regular Upward Bound projects and from other precollege math/science initiatives projects that focus on disadvantaged students. For example, compared to regular Upward Bound, MSCs typically:

- have much smaller enrollments and student-to-staff ratios and they spend substantially more dollars per student
- are more likely to be located at four-year colleges, and recruit students from TRIO projects as well as from target schools
- tend to serve students from a larger geographical area for an intensive summer and to have less contact with students in the school year, and
- enroll students who have slightly higher achievement and who express greater interest in careers requiring math or science knowledge.

Furthermore, compared to many precollege math/science projects outside the umbrella of the federal TRIO program, MSCs exclusively target students in high school in contrast to students in earlier grades, and they offer a longer residential summer program.

These aspects distinguish the MSC experience from other precollege experiences available to disadvantaged students. However, they also are associated with three concerns pertaining to the operation of MSC programs. First, many MSCs struggle to deliver precollege services to MSC students during the academic year. Sustained participation has been a widely accepted principle of good practice in Upward Bound, but it is a particularly challenging one for many MSCs. Second, the large majority of MSCs are smaller than the 50-75 enrollment range established as a target in the program's regulations. While small enrollments may represent an effective strategy for cultivating more math and science majors from the ranks of disadvantaged youth, so far little information exists

to show whether such a strategy is more beneficial. Furthermore, little information is available to shed light on why MSC enrollments have remained under ED's stated minimum. Third, most MSCs find it difficult to report information reflecting their projects' performance on outcomes such as high school achievement, college attendance, and college major. The difficulty primarily stems from a key difference that characterizes many MSCs--a single summer of intensive focus for students followed by a year or more of rather distant contact.

The remaining sections of this chapter address in detail how MSCs differ from other forms of precollege assistance and elaborate on problems that confront MSCs.

A. A DESCRIPTIVE PROFILE OF MSC PROJECTS

1. MSC Distinctions at the Structural Level

At a basic descriptive level, MSCs exhibit major differences from regular Upward Bound projects (Table II.1). First and perhaps most striking of these differences are the small enrollments in MSCs. As noted above, ED has established a goal of between 50 and 75 participants for MSCs; in comparison, it has set a goal of between 50 and 150 participants for regular Upward Bound projects. In practice, however, ED approved an average of only 46 participant slots per MSC in its 1995 award of grants. Slightly under half of all centers were funded to serve fewer than 50 students, while the remainder were approved for just 50 openings. Regular projects average 75 participant slots; moreover, regular projects that require students to take a considerable number of math and science courses as part of their Upward Bound experience (Upward Bound math/science projects) average around 85 openings--twice the approved enrollment of MSCs. Although actual enrollments can surpass the number of approved slots when projects admit students, only a few MSCs in the case

TABLE II.1

GENERAL CHARACTERISTICS OF MATH/SCIENCE CENTERS
AND REGULAR UPWARD BOUND PROJECTS

	Math/Science Centers	Regular Upward Bound
Total Number of Grants (1995)	81	600
Average Dollars Per Student Served	$5,116	$3,839
Average ED-Approved Enrollment Per Grantee (1995)	46	75
Percent of Grantees Hosted By Four-Year Colleges (1995)	88	68
Percent of Grantees Hosted By Two-Year Colleges (1995)	11	28
Percent of Grantees Hosted By Other Organizations (1995)	2	4

SOURCE: Grant award information provided by the TRIO office within the U.S. Department of Education.

studies had enrollments that exceeded their approved number of slots. In fact, the 1993-94 Annual Performance Reports indicate that fewer than 20 percent of MSCs enrolled more than 50 students.[1]

Not surprising, then, is the related and second most noteworthy basic characteristics of MSCs: federal dollars per student are one-third higher in MSCs than they are in regular Upward Bound projects. On average, this translates into MSCs spending about $1,000 more for each student during a summer than regular projects spend during the summer and academic year combined. As later sections of this chapter will make clear, these additional dollars per students are used primarily to maintain smaller student-to-staff ratios. Travel, residential costs, or higher compensation for technical instructors do not absorb a major share of the additional dollars spent per student by MSCs.

A final organizational difference between MSCs and regular Upward Bound projects is MSCs' greater tendency to be hosted by four-year colleges. Only 11 percent of all MSC awards went to two-year colleges in 1995, making two-year colleges much less prevalent host institutions when compared to the regular Upward Bound program in which two-year colleges hosted 29 percent of the projects. Postsecondary institutions housing MSCs followed no discernible pattern with respect to their overall selectivity, public versus private status, or reputation in the fields of science and engineering.

2. Federal and Local Explanations for Structural Differences

Differences in size and per-student resources are in many respects the result of intentional federal policy decisions. With regard to grant levels and the number of slots for each MSC, decisions generally are based on ED's assumptions about the funding necessary for an intensive program within the MSCs. The predominance of four-year host colleges, however, reflects the decisions of persons

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[1]The 1993-94 Annual Performance Reports are the most recent reports available for MSCs from the ED TRIO office. Although 75 MSCs were funded during that year, performance reports were located for only 70. As discussed later in this chapter, one-third of the 70 reports lack one or more pieces of information requested by ED about projects' participants and operations.

who review proposals for new or subsequent MSC grants. For example, grant proposals from two-year colleges may not present as many appealing elements to reviewers as those from four-year schools. Residential facilities, for instance, appear to be highly valued in the award of MSC grants: every MSC in the case-study sample provided a residential program. These facilities may be unavailable or extremely limited in two-year schools. Furthermore, access to scientific research opportunities may be more difficult for two-year schools to arrange.[2]

Federal decisions aside, a number of factors within MSCs reinforce differences such as small enrollment, high dollar investments per participant, and tendencies to locate at four-year host schools. Obviously, instructors' pedagogical preferences and the curricula that centers adopt are important factors related to size and cost. Both are discussed as part of Chapter III's focus on the curricular offerings of the centers. An equally important influence, however, is the service delivery model used by MSCs. For example, centers that use a regional model of recruitment must offer residential facilities to accommodate students. This increases the likelihood that they will be based at four-year schools.

B. THE PREDOMINANCE OF REGIONALLY ORIENTED SERVICE DELIVERY MODELS

The case studies of 14 MSC projects reveal that most MSCs continue to rely on ED's originally specified regional approach to recruiting students. In fact, only two appeared to rely completely on the locally oriented approach that is now an option. On the dimension of student eligibility, however, the overwhelming majority of the MSCs differed noticeably from ED's original design: 10 of the

[2]Three of the 14 case study centers were nominally based at two-year colleges. One conducted all of its activities at a nearby four-year university with residential facilities. The remaining two were located within major metropolitan areas and had access to residential facilities and science labs.

centers enrolled a quarter or more of their students directly from secondary schools or from programs other than TRIO.

In the case studies three models described the service delivery approaches employed by MSCs. These models combine the dimensions of geographical reach and prior status of participants (that is, whether students are primarily from TRIO projects or from secondary schools). The first model, the regional TRIO-based model, includes centers that target students region-wide and that serve a majority of students from the TRIO programs of Upward Bound and Talent Search. A second model, locally oriented centers, includes MSCs that recruit all students directly from secondary schools in their surrounding area--usually a city or area of a city.[3] The third model, called a "modified regional/TRIO-based model," encompasses centers that draw some, but not the majority, of their participants from TRIO projects and that target a geographic area that is either regional or subregional.

All 14 MSCs visited in the case studies employed one of these models, as shown in Table II.2.[4] Eight of the 14 used the regional/TRIO-based model described above, four used a modified regional model, and two used a local model. The regional and locally oriented models have been described in some detail previously. A bit more explanation is warranted, however, about the modified regional/non-TRIO based model. The MSCs using this model were motivated by one of two factors: the search for a more effective recruitment strategy, or the search for a design more conducive to delivering follow-up services to students in the academic year. All of the four MSCs that fell in this

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[3]While it is possible that a local MSC could serve mostly TRIO students from the nearby community, it appears improbable. None of the 14 case study MSCs were structured to operate in this manner. A TRIO-based, locally oriented MSC would require that a cluster of regular projects in the immediate vicinity provide several students each to the MSC.

[4]Because the MSCs included in the case studies were promised anonymity in any published reports, alphabetical letters have been assigned to each MSC. These are used consistently throughout this report. This convention also allows readers to recall centers' service delivery approach since the letters A-H apply to regional-TRIO based centers, I-L to the modified regional centers, and M-N to the purely local centers.

TABLE II.2

SERVICE DELIVERY MODELS OF UPWARD BOUND MATH/SCIENCE CENTERS (MSCs)

Project	Enrollment Summer 1996	Percent Students from Talent Search	Percent Students from Regular Upward Bound	Years in Existence as MSC	Ratio of Applicants to Openings	Possible Number of Summers	Academic Year Follow-Up Services
Regional/TRIO-Based MSCs							
A	51	25	75	5	2:1	1	Newsletter and phone contact
B	50	80	10	5	1.2:1	1	Newsletter and phone checks
C	42	15	60	6	4:1	3	Fall weekend of activities; intermittent phone contacts
D	50	20	50	5	4:1	3	Regular Upward Bound assistance and tutoring/counseling sessions as necessary for Local Students
E	54	36	54	5	3.2:1	4[a]	Reports from regular Upward Bound projects and financial support for local tutors
F	49	20	30	5	2:1	1	Reports from student-identified sponsors
G	52	25	50	5	2.7:1	4	Reports from regular Upward Bound; annual visit of MSC representative[b]
H	47	42	38	5	2:1	3	MSC representative visits key geographic areas;[b] newsletter
Modified Regional/TRIO-Based MSCs							
I	48	10	34	5	2:1	2[a]	Newsletter; high school math or science teachers who serve as mentors
J	40	5	25	5	1.2:1	2[a,b]	MSC representative visits to 3 key areas for 1 weekend; additional mid-winter weekend
K	44	3	7	3	3.5:1	3	MSC representative visits students in home schools twice; financial support for local tutors, as necessary
L	52	3	17	4	4:1	3	Students spend 9 Saturdays at MSC campus
Locally-Based MSCs							
M	57	0	0	1	2.4:1	4	Students spend 2 Saturdays on campus; weekly supervised study halls in home school
N	45	<5	<5	1	2:1	4	Students commit 2 hours/week to campus-based study halls; monthly field trips
Average	**49**	**21**	**32**	**4.3**	**2.6**	**2.7**	

Source: Case Studies.

[a]Fewer than 25 percent of participants are accepted as returning students.
[b]Project plans to undertake in Academic Year 1996-1997.

group originally used a regional model that targeted students from TRIO projects in their region. The actual modifications made by these MSCs ranged from focusing on either state or subregion of a state as a means to improve access to academic-year services (centers J and L), to recruiting directly from target schools because recruitment from TRIO projects in the region generated so few applicants (centers I and K).

Several characteristics--enrollment, percentage of TRIO and Upward Bound students, project age, ratio of applicants to openings, the possible number of summers a student can participate in the program, and the kinds of follow-up services offered in the academic year--are included in Table II.2 to explore how they are associated with the different models. While not every characteristic shows a systematic relationship to a specific model, a few important patterns emerge.

- ***Older MSCs rely on a regional TRIO-based model while the newest MSCs rely on a local approach.*** The link between age of project and regional orientation is not surprising, in light of the original model that grantees were required to use and the importance of priority points to the receipt of subsequent Upward Bound grants. Priority points add to the base points that all applicants receive in the competitive review process. Because priority points do not apply if the target area or population of an MSC has noticeably changed, centers that shift to local models (a noticeable change) could jeopardize their continued funding. One might expect, therefore, that local MSCs will emerge primarily as opportunities for new grants occur.

- ***Student demand, as measured by the ratio of applicants to openings, is typically twice a center's openings, regardless of MSC model.*** Although the number of students who will choose to participate in regional programs and the willingness of Upward Bound projects to send students to regional programs have been raised as issues, at this time most MSCs appear to attract an ample number of applicants. This observation is far from surprising since ED essentially allows centers with regional recruitment problems to restructure their market--whether through reaching out to students in Talent Search projects or secondary schools. Obstacles to increasing the enrollment in MSCs would appear to arise more from instructional preferences and competition with other summer programs for dorm facilities, transportation vehicles, and classroom space at the host colleges than from an insufficient supply of applicants.

- ***Services during the academic year are quite limited for many students in MSCs that use a regional or modified regional model.*** Academic-year services clearly present challenges for most regionally oriented MSCs since the services of Upward Bound

"sending" projects are available to only a fraction of students. For example, only two of the regional MSCs in the case studies drew 60 percent or more of their participants from Upward Bound projects. Furthermore, if one disregards the two purely local MSCs, only 38 percent of students in all region MSCs, on average, came from regular Upward Bound projects (Figure II.1). Consequently, these MSCs must arrange for school-year services for a majority of their students using local Talent Search projects or other forms of contact, such as newsletters or occasional visits.

- ***Participation across multiple summers is not a routine experience in MSCs with a regional or modified regional design.*** Of the 12 centers in the case study sample with these designs, half did not offer a second summer to most students. These MSCs generally saw their mission as offering a one-time experience; some doubted their curriculum would make repeat summers beneficial for most students. Others indicated students did not maintain sufficiently high grades in high school to be accepted for a second year. Additional sources confirm that participation for a single year is fairly common. Based on the 1993-94 performance reports, returning students accounted for less than 20 percent of enrollment in MSCs where students attended multiple summers.[5] In sum, the MSC experience for many students is one summer in length, and many students' involvement in the school year is minimal.

The service delivery approaches used by MSCs present an important opportunity to consider whether precollege programs that emphasize an enriched diet of mathematics and science but lower student-to-staff ratios, shorter duration across years, and minimal academic-year services are more effective than other Upward Bound projects.[6] Although the research literature generally supports the effectiveness of students' multi-year, sustained participation in supplemental programs such as Upward Bound, questions remain about the broad applicability of these norms of good practice (Burkheimer

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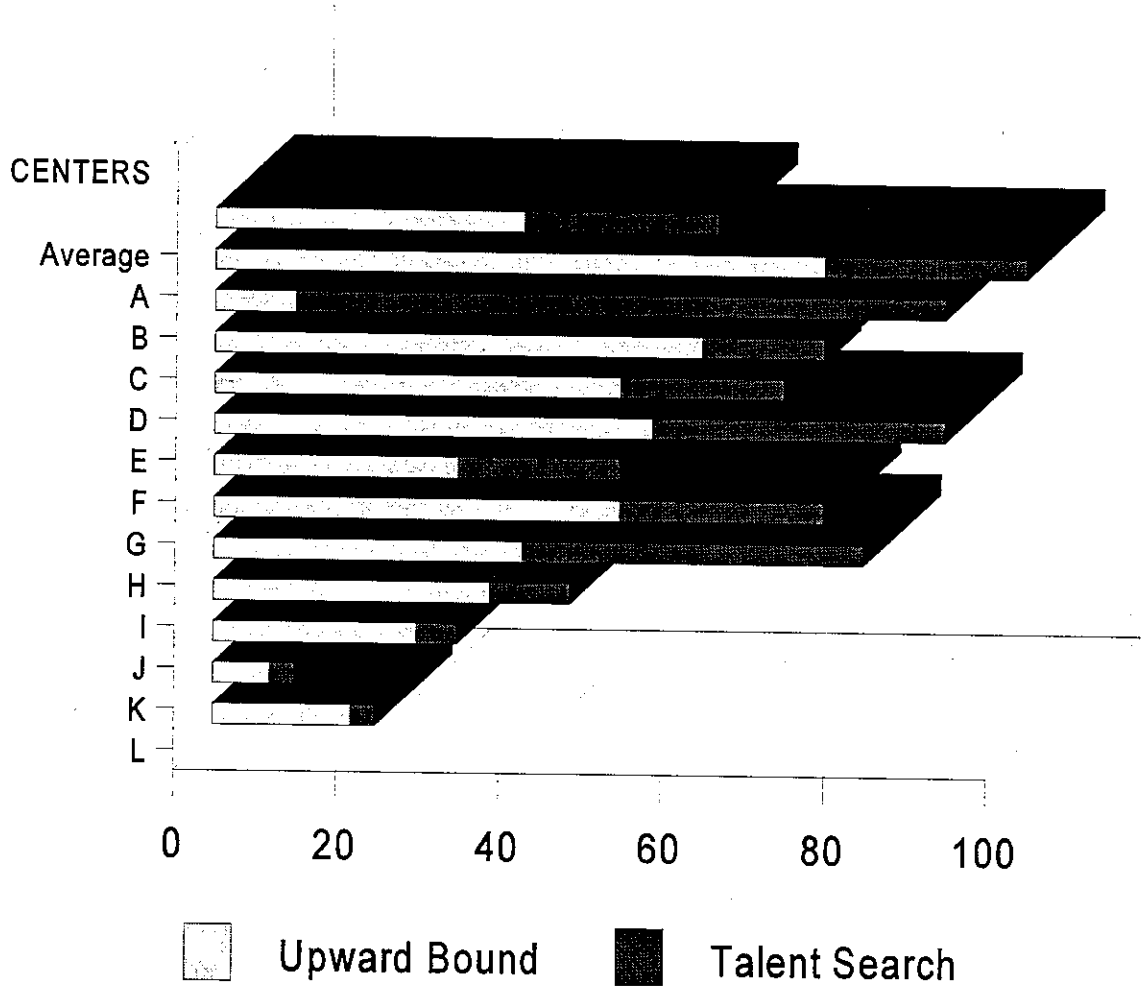
[5]These results were obtained from the Annual Performance Reports from MSCs for the 1993-94 program year. Only two-thirds of the 70 MSCs with reported data provided information about participants from prior summers. One-third of these MSCs indicated no returning students. The fraction of participants who repeat may have increased since 1993-94 in response to federal emphasis on follow-up and as grantees have had more time to develop their program.

[6]It should be noted that the extent of sustained involvement in regular Upward Bound projects is unclear at this time. Recent evidence indicates that 37 percent of students will drop out of regular Upward Bound during the first year, and that an unknown fraction are likely to leave the program in subsequent years. These observations suggest that a substantial number of regular Upward Bound students may not realize the benefits expected from continuity in the program.

FIGURE II.1

PERCENT OF UPWARD BOUND AND TALENT SEARCH STUDENTS ENROLLED IN REGIONAL OR MODIFIED REGIONAL MATH/SCIENCE CENTERS



et al. 1979, Myers and Schirm 1996). One key question that remains, for example, involves how students' entering skills may be a factor in the effectiveness of certain practices. The next section turns to a question associated with this issue in the context of the MSCs: how do students attending MSCs differ from those attending regular Upward Bound projects.

C. MSC STUDENTS TYPICALLY ARE A MORE SELECT GROUP THAN REGULAR UPWARD BOUND STUDENTS

Although students' sex and family income do not differ substantially between MSCs and regular Upward Bound projects, their racial/ethnic background does (Table II.3). The student population enrolled in MSCs is less African American and more white, Hispanic, and Asian than that in regular Upward Bound. This compositional difference quite likely comes from most MSCs recruiting at the regional or subregional level. In contrast, regular Upward Bound projects typically recruit from their surrounding communities, which often are racially or ethnically homogeneous. The consequence is a somewhat higher percentage of MSCs with no predominant racial/ethnic group than is the case in regular Upward Bound (21 percent compared to 7 percent). Nevertheless, the large majority of MSCs, like regular Upward Bound projects, have one racial/ethnic group that constitutes a majority of the student body.

1. MSCs' Selection Criteria Produce Student Differences

A fundamental difference between MSC students and regular Upward Bound students lies in MSC students having somewhat higher grades and more interest in math or science. MSCs in the case studies usually used these two criteria when they decided to accept an applicant (Table II.4). More specifically, most MSCs required applicants to have at least a C average and many MSC directors observed that a number of students in their programs maintained B averages or better. Although

TABLE II.3

STUDENT DEMOGRAPHICS FOR UPWARD BOUND
MATH/SCIENCE CENTERS AND REGULAR UPWARD BOUND PROJECTS

	Percentage of Students	
	Math/Science Centers (1993-1994)	Regular Upward Bound (1992-1993)
Sex		
Male	43	41
Female	57	59
Race/Ethnicity		
African American	44	57
White	25	20
Hispanic	17	12
Asian	9	4
Native American	6	6
Other	<1	1
Eligibility Criteria		
Low Income Only[a]	8	4
First-Generation College Only[b]	17	14
Both Low-Income/First Generation	74	82[c]

SOURCE: Math/Science Centers--Annual Performance Reports, 1993-1994. Regular Upward Bound--Fasciano and Jacobson, 1996.

[a]150 percent of the federal poverty level.

[b]Parent(s) has not completed a four-year college degree.

[c]Regular Upward Bound estimates exclude missing data on the low-income, first-generation status of 4 percent of students in surveyed projects.

TABLE II.4

MATH/SCIENCE CENTERS' ADMISSION REQUIREMENTS

Project	"C" Average or Higher	Completion of One Year of High School Science and Algebra	"B" or Above in Math and/or Science Courses	Interest in Math/Science	Other
A	√	√			
B	√	√	√		
C				√	
D	√	√	√	√	
E	√			√	
F				√	
G	√	√	√	√	
H				√	Evidence of Need
I	√			√	
J					Not Failing
K		√		√	Consistent Grades
L	√	√		√	
M	√	√		√	
N	√				Curiosity About Math/Science

SOURCE: Case studies.

grades are an important selection consideration for many regular Upward Bound projects and most students in regular Upward Bound have either B or C averages, it is less common for regular Upward Bound projects to *require* all students to have at least a C average (Moore 1996, Fasciano and Jacobson 1996).

Interest in math or science is even more frequently used as a prerequisite in the admission decisions of MSCs than is high school grade point average (GPA). Well over three-quarters of MSCs in the case studies required students to demonstrate this interest. Centers defined interest in two ways: (1) an interest in either math or science as subjects, or (2) an interest in careers requiring math or science proficiency. One MSC defined interest in math and science as "curiosity" about these subjects.

Admission requirements tied to students' interests in math and science may help explain why MSC students' average achievement tends to be higher than that of regular Upward Bound students. Information from one MSC strongly supported this speculation. Center M, a unique project because it had merged the regular and MSC Upward Bound projects at the campus, used identical criteria to admit both sets of students. The staff then identified MSC students based on a student's application stating a career interest that required some proficiency in math and/or science. These procedures resulted in the identification of a higher achieving group of students (.5 points higher in GPA) for the MSC component of the school's Upward Bound program.

2. Staff Perspectives on How Students in MSCs and Regular Upward Bound Differ

Comments from staff in the case-study MSCs support the above finding that MSC students perform somewhat better in school than regular Upward Bound students. Staff referred to a tendency for MSC students to be "more serious about school." Most staff were comfortable making such comparisons since all but two of the centers were located at colleges that also sponsored a regular Upward Bound program. Even the two centers that were exceptions claimed recent experience with

regular Upward Bound students, either through a center having previously been a regular Upward Bound project, or a regular project recently having existed at the college. Staff from the MSCs, however, frequently noted that despite these differences from regular Upward Bound, students in the MSCs were quite diverse as a group, both in their high school preparation in math and science and their general academic skills.

Upward Bound "sending" projects, although not a source of the majority of students for many MSCs, also contribute to the more selective nature of MSCs. Interviews with a few directors from regular Upward Bound projects which sent students to MSCs in the case study sample reinforced the perspective that MSC students were often among their better performing students. These directors viewed their own role as one of stimulating students' interest in attending an MSC for a summer. Such encouragement often led to identifying students for the MSC who were doing well in the regular Upward Bound program or who were among the more academically ambitious. It is interesting to note that among the sending project directors called, beyond additional paperwork, none reported disincentives to urging some of their students to apply to an MSC. In fact, they noted the incentives that stemmed from departing students creating an opportunity for the project to add students to the summer program or to operate with "a small nucleus of regular students" in the summer.

3. MSC Students Require Assistance Both in Academic Areas and in Career Development

To say that MSC students have somewhat better academic performance and more subject-matter interest than regular Upward Bound students is not to say that MSC students do not require assistance; B or C averages in many high schools are not a sufficient foundation for the successful study of math and science subjects in college. A tutor at one center noted, "In terms of algebra, these kids are not where they should be to make it to college. Our job is to give them the view to want it [college] enough to overcome their deficits." Furthermore, many MSC students' articulated interests in math

and science are broadly defined and temporary in nature. Exposure may be critical for more enduring career objectives to take hold.

MSC students themselves offer one of the best sources of evidence regarding MSC students' need for help in academics and defining career strategies. Focus groups conducted with students during the case study visits revealed that many MSC students did not perceive themselves as very good at either science or math; only a few in each focus group claimed that they did well in both subjects. Several students came to the MSC in order to improve in what they acknowledged were difficult or off-putting subjects for them. As one student proclaimed, "When I came here, I hated math...." Math and science were not the only areas where MSC students needed to improve their preparation for college. Students' proficiency in reading and writing also appeared quite weak, as observed by site visitors and as reported by the students themselves. Several students--both native and foreign born--were acutely aware that they needed to improve their verbal and writing skills.

The stated career interests of MSC students range widely. An array of careers were cited by students in the focus groups; among those cited most frequently were engineering, medicine, teaching, nursing, pharmacology, biomedical engineering, accounting, and law. For a number of students, their identified career interest was highly tentative and had developed just that summer. Furthermore, many students were uncertain about college courses necessary for entrance into specific careers. Several students in MSCs lacked a career direction. These undecided students say they participate in the centers because they believe math and science skills will serve them well in college.

All students in the MSCs saw college as their primary and immediate objective; they saw involvement in the MSC as instrumental to that objective. Not surprisingly, several students were familiar with other precollege programs and some had actually applied to a few. Often what attracted students to the MSC was the longer residential period, the types of activities offered, encouragement

from a relative, and the impression that involvement in the MSC would make on college admissions staff. As one student noted, "If you come here for education, it's a good opportunity because on the college application it's [the MSC] just going to be 'slammin.'"

D. MSCs ALLOCATE DOLLARS TO SIMILAR FUNCTIONS AS REGULAR UPWARD BOUND PROJECTS, BUT INVEST MORE HEAVILY IN STAFF-INTENSIVE SUMMER PROGRAMS

A comparison of how MSCs and regular Upward Bound projects budget annual costs reveals few differences between the two (Table II.5). Well over half of the dollars in each set of grants, on average, goes to staff support. The second largest budgeted amount provides for room, board, and tuition for college-level courses. The remaining categories of travel, stipends, and the catch-all category covering supplies, materials and other miscellaneous expenses appear roughly equivalent, at least as seen through the small sample of projects in which case studies were conducted.

There are wide variations within MSCs and within regular Upward Bound projects, however, in the distribution of costs. For example, among both types of grantees, the percentage of total funds devoted to staffing ranges from a low of 40 percent to over 60 percent. Similarly, the presence of residential summer programs, which operate in 80 percent of all regular Upward Bound projects and all the MSCs studied, influences the percentage of the budget that covers room and board. These observations serve as useful caveats regarding the extrapolation of aggregated cost breakdowns to specific projects or centers.

Quite significant differences emerge between MSCs and regular Upward Bound projects when the two are compared in terms of the ratio of students to full-time-equivalent (FTE) staff members. Table II.6 presents estimates of total staff FTEs and instructional staff FTEs attached to the summer program components of MSCs and regular projects. The table also includes similar estimates for the approximately one-third of regular Upward Bound projects with a math/science emphasis--that is,

TABLE II.5

DISTRIBUTION OF FUNDS IN MATH/SCIENCE CENTERS AND REGULAR UPWARD BOUND PROJECTS, FULL PROGRAM YEAR[a]

	Math/Science Centers[b]	Regular Upward Bound Projects[c]
Staff	57	58
Room and Board	20	18
Travel and Conferences	9	11
Stipends	3	7
Other (Supplies, Materials, Visiting Speakers)	11	7

[a]Based on budgeted allocations of costs; excludes indirect costs charged by college.

[b]Case studies of 14 Math/Science centers, 1995 costs.

[c]National Evaluation of Upward Bound, case studies of costs in 20 representative projects.

TABLE II.6

FULL-TIME-EQUIVALENT (FTE) STAFF AND STUDENT/STAFF RATIOS IN MATH/SCIENCE CENTERS AND REGULAR UPWARD BOUND PROJECTS, SUMMER COMPONENT

	Math/Science Centers[a]	Regular Upward Bound Projects[b]	Regular Projects with Math/Science Emphasis[c]
Total Staff (FTEs)	17.5	15.8	17.7
Instructional Staff (FTEs)	5.6	5.9	6.5
Student Enrollment[d]	46	80	85
Students per FTE Total Staff	2.6	5.1	4.8
Students per FTE Instructional Staff	8.2	13.6	13.1

[a]Math/Science Center Case Studies, N = 14. Summer, 1996.

[b]Fasciano and Jacobson 1996, N = 223. Summer, 1992.

[c]Special tabulation, National Evaluation of Upward Bound, Grantee Data, N = 71. Summer, 1992.

[d]Enrollment is number of openings approved by ED.

those regular projects that require students to complete a fairly rigorous blend of math and science courses during the course of a multi-year Upward Bound program.

The main difference between MSCs and the regular Upward Bound projects in the use of staff is the centers' smaller student-to-staff ratios. The ratios in the centers are smaller whether measured at the level of total staff level or instructional staff. As indicated at the beginning of this chapter, this difference occurs primarily because MSCs serve much smaller enrollments, not because the number of staff hired by MSCs differs dramatically from that of regular projects. Viewed in terms of staff resources available to students, therefore, MSCs clearly offer a more intensive program. Just as the average funds spent per student are about one-third higher than in regular Upward Bound projects, the ratio of students to staff members in the centers is about one-third to one-half lower.

The concentration of resources in the summer reinforces the observation that most center programs are not year-round. The summer and academic-year budgets for the case-study MSCs show that few staff resources carry into the academic year. During the academic year, total staff FTEs dropped to an average of 2.6 in the MSCs studied. In contrast, within regular Upward Bound projects and regular projects with a math/science emphasis, academic-year total FTEs were 6.8 and 6.9, respectively. A comparison of MSCs with only residential regular projects--an arguably more appropriate comparison--shows that the summer component in MSCs averages around 75 percent of the annual budget, while in regular projects it averages only 52 percent.

A few center programs, however, are more year-round in their emphasis. For example, the two purely local MSCs in the case-study sample were noticeably more active in their academic-year offerings than the regional MSCs. One of the local MSCs was identical in its distribution of resources to the regular Upward Bound project because the two programs were merged. The other local MSC followed a staffing pattern similar to the regional MSCs using a smaller number of FTE staff in the

academic-year component. Measured in terms of spending per pupil, these two local programs were below the average MSC expenditure. The merged project was the least expensive per pupil among the MSCs studied, largely because of a two-week residential program and economies of scale achieved through larger classes.

E. MSCs OFFER LONGER RESIDENTIAL SUMMERS AND FOCUS MORE ON HIGH SCHOOL STUDENTS THAN OTHER PRECOLLEGE MATH/SCIENCE PROGRAMS

Upward Bound's MSCs operate in an environment populated by precollege programs with a mission to improve the math/science readiness and career interest of disadvantaged youths. To what extent are MSCs distinct from these other efforts?

Although comparable case-study data are not available to address this question, information from inventories of precollege efforts in the nation can help identify where distinctions exist.[7] A review of 28 precollege math/science efforts was conducted using information compiled from these inventories.[8]

The precollege math/science efforts reviewed mainly represent interventions focused directly on students, but several represent strategies to improve the schools that students attend--for example, initiatives such as the College Board's Equity 2000 campaign that operates in several large urban school districts across the nation. Even at the student level, precollege interventions range from those that identify high achieving students to those with little selectivity, and from those focused on students' academic improvement to those with an explicit career emphasis. Some operate at the scale of

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[7]These include the 1992 publications from the U.S. Department of Education: *Reaching for College, Volume I. Directory of College-School Partnerships* and *Volume II. Case Studies of College-School Partnerships*; the 1991 edition of the American Association of Higher Education publication, *Linking America's Schools and Colleges: Guide to Partnerships and National Directory*; and the 1996 *Directory of Mathematics-based Intervention Projects*, produced by SUMMA (Strengthening Underrepresented Minority Mathematics Achievement).

[8]Appendix A of this report includes a profile of the 28 efforts according to the strategy employed, the objectives, the selectivity, the geographic outreach and location, enrollment, grade level focus, duration, and annual per pupil expenditures.

individual projects, much like a specific MSC, and address only a limited number of students (for example, the Tidewater Young Scholars Program at Norfolk State University); others operate at the scale of a nationwide program that comprises many individual projects. The Mathematics, Engineering, and Science Achievement (MESA) program, for example, includes several regional projects across four western states.

The different emphases of precollege math/science efforts and the different scale at which they operate complicate many comparisons. Nevertheless, three characteristics appear to distinguish MSCs from the other precollege math/science efforts. First, MSCs focus exclusively on serving high school students, whereas many other precollege efforts, while inclusive of high school students, serve younger students. Second, MSCs offer a longer summer residential program. In contrast to the six week summer residence of the MSCs, other precollege efforts typically last four weeks or less. Further, many do not include students' residence on a college campus. The longer duration of the summer program and its residential component clearly made a strong impression on a number of MSC students in the focus groups who noted these features led them to choose the program over other options. Third, few other precollege efforts invest as many dollars per student as do MSCs. Consistent with their shorter duration and lack of a residential component, other precollege efforts rarely exceed $1,000 in annual per student spending.[9]

F. MSC DIFFERENCES CREATE DIFFICULTIES WHEN CENTERS REPORT PERFORMANCE TO ED

Due to their distinct features, most MSCs encounter problems when they complete the Annual Performance Reports that ED requires of all Upward Bound grantees. As noted, several MSCs have

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[9]It was not possible to obtain reliable estimates of the staff-intensity of other precollege efforts. Contacted representatives did not have readily available data about staffing levels, particularly in terms of full-time equivalent positions. In some instances, projects relied upon volunteers.

their main contact with students during a single summer. These MSCs typically have difficulty in supplying more than participation counts and a demographic profile of participants; obtaining data on longer term outcomes at the secondary and postsecondary level (for example, high school graduation and college enrollment by type of institution) poses a significant problem for many. For example, well over half of all centers did not provide outcome data for the 1993-1994 program year. Moreover, centers that did provide these data varied greatly in terms of the students for whom they reported outcomes. Some reported for 12th graders as ED requirements directed, while others included all students regardless of grade.

MSCs are not unique in having difficulties with performance reports. The Annual Performance Report forms also present difficulties for some regular Upward Bound projects (Moore 1996). These problems simply are more pronounced for MSCs, even though the burden for centers may be less since they enroll fewer students than regular Upward Bound projects. For example, tracking participants for the four years after they graduate from high school is a problem for both types of projects, but it is exacerbated by the restricted period of student contact that is common to many centers. The definition of outcomes requested on the standardized form have also been a source of problems. For regular projects, restricting outcomes to 12th grade participants has resulted in an incomplete profile of project performance. For a number of MSCs, however, outcome measures based on 12th grade participation are largely irrelevant because so few students participate beyond the summer after their junior year.

Responding to increased federal emphasis on performance, most centers in the case studies were trying to improve their systems for measuring performance. Since most centers had operated for no more than five years, they had limited experience in tracking students into their postsecondary years. Many relied on informal contacts and postcards mailed to students as a tracking system. Although

some centers had established a computerized database composed of individual student records, it was unclear how easily staff could update and analyze these records. For some centers, the availability of a staff member to input and maintain the data was an issue. One center director plainly stated that no funds for this activity were in the budget.

Follow-up contacts with students in the subsequent academic year, which ED now requires of all MSCs, will improve centers' opportunities for gathering and recording short-term outcomes for students, such as grade point averages and completion of high school math and science courses. A number of centers indicated they had been collecting some of this information, but they did not often explain how it was maintained or how comprehensive it was. Several centers indicated they would soon institute steps to survey students more systematically and request schools and colleges to provide transcripts.

Long-term outcomes at the postsecondary level (for example, college majors, college persistence) were an area which many centers planned to address, but their success in finding former participants may be limited. A center director who had experience in collecting these data related that, due to students' mobility, he could track only two-thirds of the 48 participants from his center who had graduated from high school in the past four years. This center allowed students to enroll in multiple summers. Centers that limit students to one or two summers of participation face a significant challenge in successfully tracking students through high school and the postsecondary level.

III. DO MATH/SCIENCE CENTERS OFFER HIGH QUALITY LEARNING OPPORTUNITIES?

As gauged by prevailing pedagogical philosophies that stress student inquiry and teaching for understanding, the quality of the math and science curriculum in Upward Bound's MSC appears to be generally high. The large majority of MSCs incorporate practices that are in keeping with the spirit of the standards recently issued by the National Academy of Science's National Research Council (NRC) and the National Council of Teachers of Mathematics (NCTM). In general terms, these standards encourage a focus on problem-solving, scientific reasoning, and presenting students with challenging content in their math and science courses (Commission on Standards for School Mathematics 1989, NRC 1996). They urge reduced emphasis on drills, memorization, lecture formats, and global coverage, and increased emphasis on naturalistic observation, student discourse, laboratory experimentation, use of technology to analyze data, and making connections with everyday problems. The standards stop short of prescribing a precise balance of pedagogical practices, however, leaving researchers and practitioners open to differing judgments about when programs actually meet the standards.

Several findings emerge from this study regarding the general quality of learning opportunities in MSCs.

- Center programs involve a major investment of time in academic pursuits and reflect educational practices associated with the NCTM and NRC standards for math and science.
- Centers either adopt integrated (or interdisciplinary) curricula or organize instruction by discrete high school subjects.
- Most centers require students to meet demanding behavioral standards and commit substantial effort to academics.

- Centers primarily recruit qualified MSC instructors from the ranks of secondary school teachers, with graduate students the second most common source. Tenure-track postsecondary faculty rarely are instructors in the centers.

- Mentoring relationships, either with college faculty or professionals in math and science fields, are limited for most students.

These findings sound a fairly positive note about the potential educational contributions of MSCs. Many of the qualities found in the academic programs in MSCs, in fact, may offset whatever limitations come from such a large percentage of students participating for only one summer. On a less favorable note, however, these findings indicate that MSC programs generally do not give students opportunities to work with math and science professionals from the community or at the host college. If professional mentors and faculty members are viewed as critical to successful programs (as ED's program requirements suggest), then centers will have to work hard to overcome several barriers to increasing their participation that are discussed later in this chapter.

A. STUDENTS' EXPOSURE TO QUALITY INSTRUCTION IN MATH AND SCIENCE

1. Time Invested in Academics

Most educators agree that a necessary condition to the acquisition of advanced cognitive skills is the amount of time students invest in academic pursuits. The programs of study that MSCs offer clearly draw upon this axiom. One area of consistency across MSCs is a demanding summer schedule. As noted in the illustrative schedule presented in the accompanying box, MSC students typically experience an ambitious 16-hour

MATH/SCIENCE CENTER L - SUMMER SCHEDULE

AM	7:15	Breakfast
	8-9:30	Marine Biology or Natural Science
	9:30-9:45	Break
	9:45-11:15	Marine Biology or Natural Science
	11:15-12:15	Lunch
PM		
	12:15-1:45	Math
	1:45-2:00	Break
	2:00-3:30	English
	3:30-5:30	Recreation
	5:30-6:30	Dinner
	6:30-8:30	Study
	8:30-10:30	Free Time, Movie, or Games

day, filled with courses and activities. During a six-week session, students generally devote half, if not more, of their awake hours to academics, either in the classroom, laboratory, or study halls.

Centers typically assign the equivalent of double periods to the study of science and math. Educationally related activities (electives, academic counseling, and tutoring) usually are offered in the afternoons and evenings, and generally one day each week is consumed by field trips to math or science relevant sites in the surrounding area. Depending on the center, students spend from two to four hours in tutorials and study halls; while there, they are expected to complete homework assignments and developing work on their group or individual projects. At the close of the summer program, most students will log in close to 200 hours in coursework and study, an estimate that excludes the time students will spend on field trips. Placed in the context of regular schooling, this amounts to just over one-fifth of the instructional time in a full school year.

Foreign language, which is now a required offering for MSCs, is notably absent from the illustrative schedule. In fact, just half of the centers in the case studies offered a foreign language. course. Either Latin (because of its link to terms used in science) or Spanish was the foreign language offered. A few MSC directors indicated that they were still contemplating which language to offer and how best to comply with the new federal requirement. Most viewed the foreign language requirement as misguided in the context of a program specializing in math and science.

2. The Quality of MSC Instructional Time

Time spent in the pursuit of academics is merely one critical factor in acquiring the higher order skills necessary for college-level study. Consistent with the thrust of the recent standards, most educators agree that the quality use of that time is as important, if not more important, than the time invested. As noted, in recent years the NCTM and NRC standards have been the most widely accepted

criteria for assessing the quality of instructional time.[1] Unfortunately, assessments of the extent to which instruction aligns with the NCTM and NRC standards often must rely on observers' judgments about what some researchers note are primarily the surface features of instruction (for example, the use of labs, hands-on activities, and the extent of discourse between students and a teacher). Observations conducted in each of the case-study centers reflect some of the limitations of these types of judgments--limitations that recently have been brought into sharper focus by analyses of video-taped classrooms from the Third International Math and Science Study (TIMSS) (U.S. National Research Center, December 1996).[2] Nevertheless, one can be fairly confident that the case-study observations are a considerable improvement upon previous studies of learning experiences offered within Upward Bound programs because for the first time they attempted to directly verify the use of specific pedagogical practices in classes.

Most of the math and science sessions observed during the case studies of MSCs incorporated several instructional features associated with the national math and science standards (Table III.1). Almost all centers had courses that used hands-on activities, lab work, and active (or reciprocal) teaching. Hands-on activities and lab work were consistently part of the science courses; student projects--a requirement in over half of the centers--also incorporated these features. Math instruction, by and large, centered on students solving problems, either in small groups or at the blackboard. Although math classes often included use of graphing calculators, they rarely included labs or hands-on experiences for students. In general, instructors in the centers viewed math as a tool to support the

[1]The standards for mathematics instruction even more recently have been the subject of considerable debate and controversy, particularly in California. Critics assail the standards as departing too far from traditional approaches that emphasize memorization and arithmetic practice.

[2]The TIMSS analyses conducted by James Stigler of UCLA on mathematics classrooms indicate that assessments based on surface features of instruction reach erroneous conclusions about the extent to which NCTM reforms are used by teachers. Stigler, whose team analyzed videotapes, recommends developing assessments based on deeper instructional characteristics--for example, the quality of the discourse in the lesson and students' mastery of essential tasks in problem-solving.

TABLE III.1

INSTRUCTIONAL PRACTICES EMPHASIZED IN MATH/SCIENCE CENTERS

Center	Hands-on Activities	Active Teaching	Lab Work	Group Learning (Cooperative Learning)	Field Work	Student-Directed Learning
A	✔	✔	✔	✔		
B	✔		✔	✔		
C	✔	✔	✔	✔	✔	✔[a]
D	✔	✔	✔	✔	✔[a]	✔
E	✔	✔	✔	✔		
F	✔	✔	✔	✔	✔	
G	✔	✔	✔			
H	✔	✔	✔	✔	✔	✔
I	✔		✔	✔	✔	✔
J	✔		✔	✔	✔	
K	✔	✔	✔			✔[a]
L	✔	✔	✔		✔	
M		✔	✔[b]	✔		
N		✔				✔[a]
Total	12	13	12	10	7	5

SOURCE: Case studies.

[a]Restricted to students who are seniors or in their third year with the center.

[b]Reconstruction of lab facilities on campus had temporarily eliminated this feature from the center's program in 1996.

pursuit of future careers in science or technology. As a result, math instruction involved less exploration examination of real word phenomena than science classes and focused more on the application of formulas and the solution of equations.

Active teaching, a practice in which teachers encourage students to rephrase concepts and engage in back and forth dialogue about these concepts, was commonly used in math and science instruction. Cooperative learning, a technique in which students are grouped heterogeneously in small groups to learn from each other, was used slightly less extensively in the case-study centers than the features discussed above, but it was evident as much in math as in science courses. Field work and student-directed learning (in contrast to teachers' assigning topics and projects), while the least evident instructional features of those considered, played a key role in several centers. On one hand, participants in Center F were very involved in field work; they spent at least one day each week gathering and classifying fossils and vegetation from nearby streams as part of the aquatic ecology focus. The field work was so demanding that the director included a student's physical condition as a criterion for selection into the program. On the other hand, student-directed learning dominated Center I. This center provided only one week of formal instruction to students on basic methods of research. For the remaining five weeks, the students were grouped into small teams that selected and conducted research on a specific topic with guidance from one instructor.

Computers were a tool of instruction in all MSCs, but the extent to which they were used and the nature of these uses varied. Most commonly, computers were used to introduce students to applications software packages. In three centers focused either on engineering or applied research, students were taught programming fundamentals. In one center, students disassembled a personal computer that they then had to reassemble. Less impressive, however, was the restricted access that students in Center K enjoyed to the host campus computer lab. On a limited basis, students were

allowed to use computer facilities at the campus where their residential facilities were located and which was ten miles from the host campus.

3. Limited Emphasis on Course Credits

The award of high school or college credit to students who completed the center's academic program was not a major objective of most MSCs in the case studies. In only five centers did staff vigorously make an effort to ensure their students received high school credits for Upward Bound work and in only one did students receive college credit for completion of the summer program.[3] The remaining eight MSCs usually sent reports to students' schools or sending projects, but did not work aggressively with the high schools to ensure the receipt of credit. Consequently, most directors did not know what fraction of students actually received high school credits for participation in the MSC.

Regional service delivery rather than philosophic objections appears to be the reason that many MSCs take a detached stance toward the award of high school credits. Negotiating credit at a diverse set of high schools in several states is both difficult and time-consuming. Not surprisingly, the center directors that seek such arrangements focus most of their attention on reaching understandings with nearby schools and school districts. Only one fully regional center (as defined in chapter II) actively pursued high school credits for its students, but it was most successful obtaining these credits for students from the nearby community.

B. TWO APPROACHES TO ORGANIZING CURRICULUM: INTEGRATED OR HIGH-SCHOOL SUBJECT DEFINED

1. The Organization of the Curriculum in MSCs

MSCs divide over how much emphasis to place on integration (that is, interdisciplinary approaches) and on high school subjects when organizing the instructional program. About two-thirds

[3]The centers active in arranging for high school credits for students were Centers D, L, J, M, and N; the center awarding college credits was Center F.

of the centers visited in the case studies incorporated some degree of cross-disciplinary integration in their formal curriculum, while one-third formed their curriculum around the traditional college prep sequence of math, science, and English courses.[4] Either full or partial integration of curriculum characterizes the curriculum in most of the centers. Full integration typically is achieved by reliance on a skill or career path (such as scientific reasoning or engineering) that infuses the majority of courses and activities. Partial integration occurs when efforts are made to explicitly link the content covered in just a few courses.

In the remaining third of MSCs visited, the use of high school subjects to frame students' programs of study appears to take two paths--either an honors-course approach or a traditional approach. Under the honors approach, MSCs rely on fairly selective admissions and strive to identify students with academic talent; they require students to reapply and compete for openings in subsequent summers, with students' acceptance contingent upon maintenance of a specified GPA in their high school math and science courses. Centers that follow the traditional approach are less concerned with students' initial talent; instead they seek to strengthen students' high school performance in math and science by addressing key concepts in subjects students will take in the subsequent year. These centers automatically invite all students who show effort to return the next summer and give them first claim on openings.

2. Pros and Cons of Each Curricular Format

There is little guidance in the NCTM and NRC standards about whether interdisciplinary curricula are more desirable than subject-discrete curricula. The math and science standards stress two dimensions of learning as crucial: (1) knowledge of the enduring and important concepts; and (2)

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[4]Appendix B includes a description of the curriculum within each of the 14 MSCs in the case-study sample.

cognitive processes that can make sense of that knowledge. The standards cite reasoning, problem-solving, communicating, and making connections as among the most critical cognitive processes to develop. Despite highlighting the importance of making corrections, however, the standards do not directly address the superiority of an integrated or interdisciplinary curriculum (for example, teaching math concepts in science classes) over a discrete-subject curriculum.

Indeed, positive results can be ascribed in theory to either type of curriculum. Arguably, an interdisciplinary curriculum facilitates students' ability to make connections across bodies of knowledge and give them understanding of how concepts come together in real-world applications. Students also may be particularly drawn to learning modes that depart dramatically from those typically used in high school. But it is also possible for a syllabus based on traditional high school math and science courses to foster students' conceptual knowledge and performance in high school while still allowing real world applications and connections to enter class discussions. A curriculum defined by high school subjects also may appeal to students because they can see their summer course of study as immediately relevant to the next school year.

The motivations behind adopting an integrated or high-school defined curriculum appear to reflect the different priorities that MSC staff assign to these alternative propositions about learning and student interest. Proponents of integrated curricula place a high priority on a sustained immersion in careers or activities that apply the concepts of math and science in order to inspire students to achieve in their high school courses. Proponents of the high-school framework assign top priority to students' developing proficiency in high school science and math through challenging and creatively taught content.

These differences in priorities are well illustrated by the contrasting curricular emphases in two case-study centers. Center C uses a fully integrated curriculum in which every course builds on field work in marine science--the center's primary focus. In the evenings, however, Center C runs classes

that prepare students for their upcoming high school subjects--a secondary objective in this center. The organization of the curriculum in Center N reverses this pattern. For four days each week students take courses that correspond to the familiar college prep sequence of math, science, and English, thus accomplishing the center's primary objective of preparing students to do well in high school. On the fifth day, however, students take field trips intended to demonstrate how the concepts and skills from traditional subjects are applicable to the environment and industry--the center's secondary objective.

Students in the focus groups held positive opinions about the instructional program regardless of which curricular path a center followed. Perhaps these views would be expected since students' experiences were limited to the center in which they participated; an easier point of reference for students was the curriculum they experienced in their high schools. Against that standard, students were quite enthusiastic in noting the differences--again, regardless of the curricular approach used by a center. For example, according to students, the teachers and the tutors in the centers really cared about how students did their work, while many high school teachers did not. Moreover, they believed the small classes made it easier to learn. Several students observed that the coursework related much more to real life experiences than was the case in high school, and the overall program provided opportunities through field trips and labs that students otherwise would not have. Students were critical of instructors who lectured the class or appeared disengaged from students in the course. A few centers had one or two such teachers, whom project directors readily acknowledged were recent hires who had not worked out as well as they had hoped.

3. MSCs Offer Less Traditional High-School Curricula Than Do Regular Upward Bound Projects

The question of how high a priority to place on content taught in high school versus academic experiences that go beyond the high school curriculum confronts both regular Upward Bound and MSCs. Resolution of this issue logically precedes any decision to offer an integrated curriculum,

which invariably will differ from the curriculum in most high schools attended by disadvantaged students. But the content of a curriculum defined by traditional subjects also can extend beyond what students typically receive in their schools. The most recent evaluation of the regular Upward Bound program refers to content beyond the typical high school curriculum as a focus on *enrichment*, and content typically covered in students' high school courses as a focus on *support* (Moore 1997).

Not surprisingly, application of these terms to the MSCs in the case studies results in about three-quarters identified as focused on enrichment. In comparison, just over half (53 percent) of regular Upward Bound projects are categorized as having an enrichment focus with the remainder divided between emphases on support or remediation (that is, the review of content previously taught).[5] An even more dramatic contrast between regular projects and MSCs concerns the use of interdisciplinary curricula. Only one-third of regular projects compared to almost two-thirds of the MSCs studied relied on interdisciplinary themes. These patterns highlight those discussed in the previous chapter, confirming that, from a curricular perspective, MSCs differ in important ways from regular Upward Bound.

C. THE CURRICULUM BEYOND THE CLASSROOM

Coursework and group projects embody the formal academic curriculum; the expectations and rules that govern students' daily lives form another dimension of the curriculum that MSCs attempt to teach. Within most MSCs, as within many regular Upward Bound projects, considerable energy is directed to this facet of the curriculum, which centers on developing self-discipline, a dedication to

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[5]Since the recent study of regular Upward Bound did not include course observations, the methods used to develop these comparisons differ. Directors in a representative sample of regular projects responded to a survey question asking about the extent to which they focused their summer and academic-year programs on teaching material covered, beyond, or already covered in the normal high school curriculum. In the case studies, site visitors made these summative determinations. In a few MSCs, staff indicated that some review of previously taught material (remediation) was conducted for some students.

academic effort, respect for others, and a compliance to structure. In the context of regular schooling, educational researchers often use the terms "informal" or 'hidden" curriculum to refer to this less structured dimension. Such terms seem slightly misleading, however, when applied to situations such as Upward Bound in which rules and students' comportment are viewed by the staff as highly intentional parts of the learning process. Nevertheless, in the absence of more precise terminology, this report will continue to apply the adjective "informal" to this dimension of curriculum in Upward Bound projects.

1. Content of MSCs' Informal Curriculum

MSCs adopt a very similar set of behavioral rules that cover a wide scope and apply to all students who participate in the summer program. Centers with an academic year program that involves regular contact with students apply these requirements year-round. MSC rules govern students' dress, language usage, completion of homework, class attendance, promptness, curfew, and mandatory participation in scheduled events. They also include prohibitions on physical violence, weapons, and any use or possession of alcohol or drugs; limits on the use of TV, phone, and stereos; and bans on disrespectful remarks or the display of inappropriate "attitude." Typically, all staff (instructors, resident advisors, counselors, and tutors) can issue formal warnings and "write-ups" for infractions of these rules. Consequences stemming from infractions vary across centers, but the first response usually involves the student in an immediate meeting with the academic counselor or project director, at which time an appropriate penalty and/or remedial action is decided upon. Deductions from students' stipends (a full stipend is typically $15 per week in the summer) and the withdrawal of other privileges (movies, recreation periods, trips) are common penalties. Dismissal from the program exists as a possible consequence in every center, and one which a number of centers in the case studies had

exercised. Centers vary with respect to permitting dismissed students to reapply for a subsequent session.

Academic effort inside and outside the classroom is also a key component stressed by most MSCs. Students are expected to be persistent; to seek help from instructors, tutors or their own peers; and, in many centers, to maintain a specified GPA. Lack of effort can be cause for a student being asked to leave the program. Usually, instructors provide mid-session grades in all courses for proficiency and for effort. In a number of centers, weekly or bi-weekly grades are issued--and some attach incentives to grades above a certain level (for example, ice cream tickets, awards, and even placement in the residential component of the program).[6] Quite often students accepted into a center are required to sign a statement of their commitment to the academic and non-academic requirements of the program. These statements provide a basis for counseling discussions during the course of the program, if students run into difficulty in these areas.

Program survival and pedagogical purposes lie behind the framework of discipline and personal engagement imposed by MSCs and regular Upward Bound projects alike. Directors often indicate that students' basic security requires strict rules; further, they claim the program's privileges and access to campus-wide facilities depend on how the students are perceived on campus. Equally, if not more important, however, are the pedagogical objectives that many directors and instructors see expressed in the expectations and requirements that are so prevalent in Upward Bound projects. Among these are:

- developing self-sufficiency, time management skills, and effective ways to address problems and people when living at college

[6]Only one center in the case study sample did not operate a residential program for the entire summer session. This local center provided a two-week residential experience for a majority of its students.

- conforming to external rules and a structure that fosters knowledge and skill development

- building self-confidence based on accomplishment of smaller, intermediate requirements, and

- learning to put academics first.

2. MSCs Tend to Impose More Expectations and Requirements on Participants Than Do Regular Upward Bound Projects

MSCs often demand more adherence to behavioral expectations than do regular Upward Bound projects. MSC students in the case study sites frequently had earlier curfews, stricter limits on joining other groups' social activities, and more demanding effort requirements than students enrolled in the companion Upward Bound program at the host college. The slightly higher achievement of MSC students and widely shared perception that they are more serious than regular Upward Bound students seemingly would make them candidates for less demanding rules and effort standards. MSC staff apparently have reached a different conclusion, however. They conclude that it is important to inculcate the discipline and mindset necessary for students to meet the extra demands that success in math and science will require.

The effects of this perspective are somewhat unclear. Do students internalize the message or are they put off by the vision of a highly disciplined existence? Students in the focus groups acknowledged that some students bridled at the rules and what they saw as unnecessary regimentation; other students observed that "while it [the set of rules] took some adjustment, it definitely was something you can live with." Others acknowledged the value of what some students saw as staff intrusiveness. One student who had run afoul of program rules spoke about the importance of the academic counselor and resident advisor teaming up and "getting on his case." Their interventions conveyed to him that these adults had confidence that he could succeed--a confidence that he now was

able to have. A final source of evidence that most students are not put off by the informal curriculum of the centers is the sizable number of applications that MSCs receive. Clearly, many students are willing to accommodate themselves to the program requirements and personal regimen that distinguish MSCs.

D. QUALIFICATIONS AND ROLES OF CENTER STAFF

The best designed curricula are unlikely to succeed without skilled staff who are competent in their roles and committed to students' progress. The federal government clearly intends for MSC staff to possess training and experience in math and science, presumably to be effective teachers, but also to serve as role models and mentors for students. Specifically, federal requirements include the staff's formal training or work experience in math and science as key factors in the review of a center's proposal. Further, federal rules require that centers arrange for the participation of math and science faculty or professionals in the community who work in research or applied science, in order that students can learn directly from them. Finally, the federal requirements state that centers must include tutors and counselors who are graduate or undergraduate math and science majors.

1. MSCs Typically Recruit Instructional Staff with Math and Science Backgrounds

Almost all instructors and tutors who were teaching math and science courses in the case-study MSCs had backgrounds linked to these subjects. Moreover, a majority of project directors possessed a background in math or science. Several noteworthy patterns emerged with respect to the backgrounds of staff comprising the typical MSC instructional team and the roles that staff members adopted.

- ***Instructors***. Although staffing configurations varied, the majority of math and science instructors in MSCs currently were or recently had been high school teachers who were certified to teach these subjects. Graduate study was the second most common background of instructors. (See Figure III.1.) Instructors usually saw their roles as

primarily instructional and did not consciously strive to be mentors or role models to students.

- ***Tutors***. All centers employed tutors, several of whom served as course assistants in addition to formally tutoring assigned groups of students. Tutors were either undergraduate or graduate students and often attended the host institution. Most math and science tutors (as distinct from English tutors) had math or science related majors or were graduate students in such fields as engineering, marine science, and medicine. Along with resident advisors in the dorms, tutors generally were clear role models for students.

- ***Project Directors***. Eight of the 14 directors in the case study MSCs had either majored in math or science or had obtained an advanced degree in a scientific field. Rarely were directors among the tenure-track faculty at the college, however, and few took on instructional roles in the center. Importantly, several directors with math and science backgrounds exerted considerable influence over the academic content of the curriculum followed in their centers.[7]

- ***Tenure-track College Faculty***. While there were some exceptions, seldom did college professors serve as instructors in the centers. The reasons for their absence were professors' desires to concentrate on research grants during the summer months and to undertake nonteaching assignments, often at other locations. Higher salary costs also were a factor, as was the competition for professors' time that came from other summer programs at the college.

The hiring strategies followed by the MSCs generally succeeded in producing a qualified instructional team. Instructors who were high school teachers were rated very favorably by directors and students alike. Secondary school teachers were less expensive than college faculty, had more classroom experience with teenagers, and often had training in the techniques associated with the NCTM and NRC standards for math and science. High school teaching experience, however, was not the only type of background associated with skill in the classroom. Several of the graduate students and adjunct college instructors whom the centers had hired were also considered effective. Overall, course observations and interviews with various staff during the case study visits revealed that, with

[7]The directors without a math or science background were highly influential over the centers' operations but tended to delegate curriculum development to academic counselors or specific instructors.

the exception of a strong preparation in a math and science related field, no particular background could be consistently counted on for producing effective pedagogy in carrying out a center's curriculum.

Similarly, the presence of project directors with math and science backgrounds does not appear to be closely associated with the quality of instruction offered in MSCs. A director's background in these subjects, however, may be linked to a center's offering an integrated curricula. Two-thirds of the centers with an integrated curriculum had such project directors, while just two-fifths of centers with high-school defined curricula had directors with a math or science background. Nevertheless, the overall instructional quality--as judged by the inclusion of instructional features associated with the national standards for math and science--did not seem to be impaired when directors had little technical training. These directors usually hired staff who filled the potential leadership gap related to content--for example, curriculum specialists, academic counselors, or specific instructors.

2. Conditions Viewed as Key to Successful Instruction and Staff Retention

The conditions surrounding instruction are important factors in MSCs' attracting and retaining qualified staff, and in creating an environment favorable to instructors' full use of their knowledge and skills. Generally speaking, few MSCs in the case studies had problems in recruiting and retaining instructional staff, although occasionally a few specific hires did not work out as well as directors had hoped. In fact, only one center (Center I) reported difficulty in attracting qualified instructors, which may be partly explained by its relatively remote location. Typically, however, MSCs relied upon a core of instructors who returned each summer and were able to guide new members of the instructional team. The two main reasons that instructors gave for returning were (1) their belief that they could

teach effectively in the centers because of the size of the program and (2) the students' willingness to work hard.[8]

Enrollment levels and course size, in instructors' minds, were critical features that attracted them to the centers and that should not be changed. Although some project directors could foresee some benefits from enlarged enrollments--they typically cited an increase of 10 to 20 percent of current enrollment as appropriate--seldom did instructors concur with this view. Instructors offered the following considerations when questions of larger enrollments were posed:

- Instructional techniques used in the centers (for example, labs, field work, and student projects) were based on working with relatively small groups of students. One instructor observed that she would have to change her practices considerably if classes were larger. Fifteen students per course was the maximum, in her opinion.

- The scale at which centers currently operated (that is, between 40 and 50 students) allowed the instructional team to meet daily or twice-weekly to review individual students' progress and to share ideas for program improvement. In some centers, instructors used daily meetings to plan for ways to integrate the curriculum--an activity that larger groups of students made more difficult.

It should be noted that few staff--instructors, tutors, or directors--thought that centers could effectively serve more students without corresponding increases in resources. Issues of dormitory space, transportation (for example, the seating capacity of a bus or van), and need for additional staff were their major resource considerations. Even with increments of funding to cover such costs, however, instructors consistently agreed that if more students were to be served as part of the UBMSI, increasing the number of centers would be a wiser strategy than enlarging the enrollments in already existing centers.

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[8]At least half of the instructors were employed less than full time during the summer session. This condition, in addition to the period of employment lasting less than two months, is likely to appeal to the staff recruited as instructors. One instructor cautioned, however, that few instructors could be effective if they only sought to work the minimal number of hours.

Adequate time for planning and preparation of courses was rarely a condition that instructors raised as an issue that affected either their performance or decision to work at the centers. Instructors' lack of concern regarding available planning time is somewhat surprising. Few centers provided reimbursed time for instructors to plan courses prior to the summer session. Typically, the centers formally convened instructional staff for a few days (two days were quite common) in advance of the summer session to prepare their courses. Some centers reported holding informal meetings with individual instructors or teams of instructors in the spring before the summer session to gather ideas and begin to pull course syllabi together. The presence of well-developed course content that required only fine-tuning by an instructor and the use of several instructors who had previously taught in the MSC program are likely explanations behind this lack of concern regarding the limited time available for course development and preparation.

3. Infrequent Mentoring from College Faculty and Professionals in Math and Science Occupations

Mentoring by college faculty and outside professionals across the case-study MSCs was extremely limited. Only one MSC (Center B) offered students an extensive mentoring experience consisting of three hours each week working in labs with professors and their graduate students. Two centers (Centers C and D) planned to implement a mentoring component next summer that would pair seniors with college faculty mentors and nearby professionals in engineering or marine science. A fourth center (Center J) included a mentoring segment in which groups of four students spent at least one afternoon with a professional employed in a math or science related occupation. In past years, some of these mentors followed up on this session through arranging additional meetings with one or more students in the group. To satisfy the federal grants program's requirements for some form of direct involvement with college faculty and professionals, the remaining 10 centers relied on field trips to technology-focused firms or governmental entities (for example, NASA or Oak Ridge Laboratory) and

a series of speakers to introduce students to role models, who might evolve at some point into mentors for students.[9]

The difficulties centers encounter in attempting to arrange mentoring opportunities are very similar to those they encounter in attracting tenure-track faculty as instructors. They must compete with other educational programs seeking to provide students with practical experiences for mentors' time. Moreover, many candidates have insufficient time to devote to working with a student. One center director who had abandoned efforts to develop mentoring opportunities observed that the time invested was not worth the outcome. He found a limited supply of mentors and those whom he did recruit performed unevenly in terms of how well they related to students; instructors, he claimed, were much more effective in helping students acquire necessary knowledge and skills to advance in math and science fields.

The upshot of these observations is that structured mentoring opportunities simply may not be feasible in a large number of MSCs. Although it may be useful to encourage centers to create such opportunities, federal program managers may have to consider the obstacles that most centers appear to encounter in this area.

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[9]The federal requirement only calls for MSCs to arrange for the involvement of college faculty and professionals in careers dependent on math and science skills. The use of such persons as mentors is not explicitly stated, although mentoring roles are clearly in keeping with the spirit of the requirement.

IV. HOW DO MATH/SCIENCE CENTERS INTERACT WITH OTHER PROGRAMS AND INSTITUTIONS?

Most MSCs focus heavily on the students attending the center and interact with other programs and institutions only out of necessity. Staff in the MSCs relate to programs and institutions outside of the center--for example, regular Upward Bound projects, other precollege programs, target high schools, and parents--almost exclusively in terms of key functions related to recruiting and serving students. The interactions typically involve matters of applications, students' arrivals and departures, social activities, students' academic and comportment reports, and academic year follow-up activities.

A consistent pattern emerged across the MSCs in the case studies with respect to their interactions with external entities. For example, centers generally:

- operated separately from the regular Upward Bound project and other precollege programs at the host college
- had little contact with other Upward Bound, Talent Search, and precollege projects, except to the extent these projects were recruitment sites for an MSC
- provided few opportunities for parents to be formally involved, and
- beyond recruiting, had a limited presence in students' high schools.

The circumscribed nature of most MSCs' interactions--more circumscribed than those of regular Upward Bound projects--is not surprising given the scheduling and geographic issues faced by most centers. Little time exists in the summer--the focal point of most MSCs' programs--to engage in efforts that require much logistical coordination, and during the school year geographic distance makes collaboration with sending Upward Bound projects, target high schools, and parents difficult. Yet by limiting external collaborations, centers may fail to reap several advantages that may derive from greater involvement with programs and institutions outside the center--for example, advantages such

as the cross-fertilization of curriculum, economies of scale in certain areas, and sustained reinforcement from other parties who influence students. Limited involvement may also mean missed opportunities to more broadly improve the math and science instruction of a number of disadvantaged students. Other precollege programs and high school staff conceivably could profit from adopting some of the approaches and curricula used within MSCs. In short, increasing staff time invested in relationships with external parties could benefit MSC students and spill over to students in other settings.

A. MSCs' COLLABORATION WITH PRECOLLEGE PROGRAMS ON CAMPUS

1. Limited Collaboration with Regular Upward Bound Projects

Regular Upward Bound projects are almost always present on campuses where MSCs are located. In 1993-1994, 88 percent of all MSCs were located at a college that also hosted a regular Upward Bound project. A similar percentage of the 1996 case-study MSCs co-existed with regular Upward Bound projects. In fact, only two centers in the case studies were at host colleges that lacked a regular project--and in only one of these cases was that by design of the host institution.[1]

Despite a common host, however, MSCs and regular Upward Bound typically functioned in relative isolation from each other. This situation prevailed in the case-study MSCs, even though both programs frequently reported to the same administrative official at the college (usually the TRIO coordinator) and some even shared the same project director. The interactions that did occur between MSCs and regular projects usually involved recreation, social occasions, and dining. In only a few

[1]In the case of Center I, the regular project had recently lost its grant. In the case of Center N, the host institution elected to replace its regular project grant with an MSC grant in the most recent competition.

cases did both programs use the same dormitories and were students from each actually assigned as roommates.[2]

This pattern of separateness was punctuated by a few exceptional circumstances. One center (Center C) operated the entire MSC program at a different college from the host institution where the regular Upward Bound project was located; in effect, there was no joint presence of both programs at this host. Another center (Center M) had merged both programs to the point the programs were indistinguishable from each other, except for certain field trips and electives available to each group of students. Although a merged program was not the original plan, the staff felt pressed to respond to a shortfall in funding from the level initially requested as a grant for the center. Their response was to create a large unified Upward Bound program (around 100 students combined) to permit an adequate level of services to the new group of MSC students.

These instances aside, the ten remaining case-study centers operated quite separately from regular Upward Bound projects at the host institution except for occasionally shared social activities. This situation has not been viewed as desirable by all staff involved, however. Some MSC staff (and others in the TRIO offices on campus) observed that harmful messages are likely to result from a rigid separation of the two groups of students. These messages included perceptions that students in the MSCs were superior and elitist. The potential for these messages arising sufficiently concerned the staff in two centers that they have taken steps to purposely build areas into the two programs that will combine students from both groups.

If program boundaries may engender inappropriate messages, why do centers and regular projects establish these boundaries? Center directors and their staff noted several contextual differences in the

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[2]Importantly, MSCs rarely allowed students from the regular Upward Bound project at the college to leave that program in the summer to enroll in the center's program. Presumably, this minimizes competition for the same students in the surrounding community and prevents internal disputes arising within the host institution.

programs that encouraged separation. For example, three institutions had non-residential regular projects and a fourth offered residence only to seniors; in some cases students in regular projects that were residential were required to live at home on the weekends. Often staff noted that the MSC and regular Upward Bound projects were located in different buildings or on different floors. Such arrangements, however, are likely to have resulted from decisions based on factors other than the happenstance of where space is available on campus.

Overall, two fundamental reasons explained why most institutions maintained separate programs: (1) each staff's need to exert control over the specific group of students who were in their charge, and (2) a view that the regular Upward Bound project was remedial and less demanding, and as a result would detract from the objectives of the MSC. The latter reason clearly has the potential to send a negative message to students in regular Upward Bound--namely, students' participation in a remedial program suggests that they need a great deal more assistance to learn than students in the "other" program and their program does not offer challenging content. Such a message is inconsistent with a growing body of research on improving the academic performance of disadvantaged students. This research stresses the benefit associated with challenging academic content that affirms students' cognitive strengths and conveys high expectations (Steele 1992 and updated).

A third pressure behind the level of separation that characterizes MSCs in coexistence with regular Upward Bound projects may be expectations that MSCs should offer students an experience different from what they receive in regular projects. If the two programs resemble each other too closely--a situation which might occur when there is considerable sharing of activities--the rationale for both grants may be called into question. This sensitivity applies both at the level of host institutions and the federal government. Concerns about ample separation permeate the federal and local institutional environment in which MSCs and regular projects operate, but they are not always visible. While directors in the case-study MSCs did not articulate a federal or institutional pressure for separation,

that so many assumed the insularity of the two programs was desirable may indicate that these expectations have been largely internalized.[3]

Two centers were making an increased effort to reduce the extent of separation and send an affirmative message to students in both programs. These centers sought to exploit areas where mutual activities can occur without undermining the integrity of both programs. Their approach to linking MSCs and regular Upward Bound projects mirrors the typical postsecondary framework for linking students with different college majors. Specifically, students with different majors usually share dormitory space and are free to enroll in electives outside their major fields of study. Moreover, all students abide by one general set of behavioral requirements, although the standards for maintaining standing in one's major may differ in terms of stringency.

LINKING MSC AND REGULAR UPWARD BOUND CENTER D

Under the direction of the same project director and a full-time assistant project director, the math/science center offers joint activities, meal times, and Friday field trips with regular Upward Bound. Except when regular project students go home for weekends, they and center students attend the same activities (for example, recreation, picnics, and competitions). Regular Upward Bound is residential only for seniors. Nevertheless, these students and MSC students live on the same floors in the dorms. Room sharing, however, is infrequent. Furthermore, students from both programs can enroll in the same two afternoon electives--Spanish and Gospel choir. The two groups are separated for their other coursework.

Application of these principles to the relationship between MSCs and regular projects at the same campus translates into the following possibilities: shared dormitory space, one common set of behavioral rules relating to the residence and movement about the campus, and a number of combined electives, field trips, and activities. The description of Center D's efforts to reduce the separation

[3]The case studies did not include interviews with staff from the regular Upward Bound project on campus. The presence of shared project directors in several centers provided some insights into perceptions inside the regular project. MSC students in focus groups occasionally acknowledged the presence of the regular project and complained about the less exacting social rules regular students enjoyed.

between the center and regular Upward Bound project on campus illustrates such an approach in practice. It suggests that a more salutary blending of Upward Bound programs may be possible than is presently the case at many institutions.

2. Other Precollege Programs on Campus

Given the distance that characterizes MSCs and regular Upward Bound projects at the same campus, it is not surprising that MSCs have few interactions with precollege programs that are not affiliated with Upward Bound but also located at the same host institution. Four centers were located at large universities that sponsored a number of precollege programs beside Upward Bound. One center director reported the presence of at least 40 such programs on the campus, but the other three cited numbers between 10 and 20. Some precollege efforts were state supported while others drew upon national sources of funds from agencies such as NASA.

Little collaboration existed between the MSCs and these programs for many of the same reasons cited above--the need to exert effective control over groups of teenagers and different pedagogical emphases. However, an additional layer of difficulties derived from different eligibility requirements, schedules, and program objectives of these other precollege programs. Although competitive pressures emerged among programs in areas such as obtaining the participation of college faculty and space, these pressures did not appear as a major explanation for lack of collaboration.[4]

B. MOST INTERACTIONS WITH ENTITIES OUTSIDE THE HOST INSTITUTION ARE CONFINED TO STUDENT RECRUITMENT AND FOLLOW-UP

There are a range of entities off campus with which MSCs might logically collaborate since they share similar concerns relevant to preparing students for college and future careers: other regular

[4]At Center M, the central administration had embarked on a plan to convene all precollege program directors on campus to share approaches and issues. Administration envisioned two to three meetings over the course of a year.

Upward Bound projects, the schools attended by MSC students, and other precollege or math/science programs and initiatives. Generally speaking, MSCs' involvement with these entities is defined by the need to recruit and follow-up with students. Therefore, the service delivery approach adopted by a center--namely, whether it is regional, modified regional, or local (as described in Chapter II of this report)--greatly influences the entities with which an MSC interacts.

Below, the nature of MSC involvement with each of the external groups or organizations is summarized.

1. Regular Upward Bound Projects at Other Host Institutions

Regionally oriented MSCs are the primary group that interacts with regular Upward Bound projects at other institutions. Most formal exchange between regional MSCs and sending projects occurs in the areas of recruitment and follow-up--not on matters of curriculum or project design. However, a few MSC directors had received informal requests from new project directors in their area for advice on student handbooks, program structure, and recruitment materials. One director also noted that she had been part of a round table dialogue at a regional conference focused on how to plan and structure summer program components.

Some indirect opportunities for sharing curricular design and content do occur. MSC students who return to a regular project sometimes provide information to the regular project about curriculum in the MSC, and vice versa. Furthermore, becoming informed about which centers to encourage students to attend permits regular and MSC project directors to share ideas. To what extent these informal arrangements result in meaningful dissemination of strategies for improving program practices is unclear.

2. High Schools Attended by MSC Students

Unless MSCs recruited students directly from a set of target high schools, their interactions with high schools involved occasional speaking engagements and discussions regarding students' performance during the school year. The MSCs that did recruit from target high schools had much more frequent contact with the schools; directors and counselors often made appearances to recruit students and motivate their interest in math and science. Contacts with specific counselors and teachers to monitor students' progress were much more common among this group of centers. The level of collaboration observed for MSCs appears very similar to that found in regular Upward Bound projects, most of which have formalized arrangements (for example, appointed liaisons) with nearby target schools. However, as reported elsewhere, the scope of projects' involvement in target schools, even for regular Upward Bound, is limited mainly to recruitment (Moore 1997, Waldman 1996). Few regular projects engage in teacher workshops or collaboratively plan course content, as is true for most MSCs.

Two locally oriented centers in the case studies (Centers M and N) displayed a fairly robust presence in nearby target schools that appeared even to go beyond the norm for regular Upward Bound projects. Because both centers worked with no more than five high schools, a staff member from the center could be present one day each week during the school year at each school. This weekly presence enabled the assigned staff member to follow-up with MSC students on various issues, to recruit new students, to contact faculty in the high school on concerns about individual students, and generally to become acquainted with the functioning of the school. Both centers also used this base within the school (the school administration made a desk and phone available to the counselor on their day in residence) to coordinate the MSC curriculum with that of the high school and to monitor students closely (for example, to insure students' schedules included the appropriate college prep courses).

3. Other Precollege and Math/Science Initiatives External to the Host Institution

MSCs' interactions with other precollege programs were highly idiosyncratic and largely a function of individual staff members' networks. For example, a few directors routinely referred applicants and participants to other appropriate precollege programs. In Center B, for example, the director and staff recommended follow-on programs for participants to attend after they had completed their summer at the center. In Center D (which focused on engineering), staff regularly recommended alternative MSC and other precollege programs to applicants whose career interests were not in the engineering field. This center also strove to identify particularly supportive programs at other colleges in which their graduates would have a better chance of completing a degree in engineering.

Although few direct channels currently link MSCs to other major math/science initiatives, several centers have been indirectly influenced by such efforts. At the time the UBMSI was launched, the federal government encouraged centers to establish cooperative relationships with other federal and non-federal science and mathematics reform initiatives. The government listed such initiatives as the Eisenhower Math and Science Education programs, National Science Foundation sponsored activities in the area, and nearby federal laboratories engaged in math and science education. Over six years later, there appears to be few formal linkages between MSCs and these initiatives. However, centers' heavy reliance on secondary school teachers indirectly allows the centers to profit from professional training efforts focused on best practices in math and science curriculum and instruction. The grant proposals from centers in the case studies and their course syllabi also reveal considerable awareness of principles embodied in the NCTM and NRC standards. Clearly, several of the centers visited used curricular materials reflecting these standards. Furthermore, in a few instances, specific faculty members advised center staff about pedagogical techniques with promise for math and science education. The centers, while in touch with the instructional reforms for math and science teaching, did not function as major dissemination channels themselves.

C. MOST MSCs OFFER FEW OPPORTUNITIES FOR FORMAL PARENT INVOLVEMENT

Distance and the relatively short duration of many students' involvement with a center are obstacles to MSCs' engaging parents in on-going activities that equip them to reinforce the math and science pursuits and persistence of their children. These obstacles primarily limited the parental involvement opportunities in centers using a regional or modified regional service delivery approach. Local centers and centers serving several students from the nearby community, because they were more favorably situated, provided more frequent formal opportunities for parent involvement.

Parental contact in most centers relied substantially on parent-initiated contacts; the formal opportunities for parental involvement generally included interviews at the time of application, an orientation session prior to the summer residential program, and a student awards ceremony to which parents are invited. Regional centers take a parent's inability to travel to the host institution into account by making most of these activities voluntary. Compared to regular Upward Bound projects, MSCs' occasions for parent involvement were less frequent and covered a narrower range of activities. However, it is worth noting that even the opportunities provided by regular Upward Bound projects, while numerous in terms of the kinds of activities (for example, financial aid workshops, home visits, and discussions of written evaluations), typically occurred only once each year (Moore 1997, Fasciano and Jacobson 1997).

Although most MSCs are characterized by limited parent involvement opportunities, a few exceptions emerged in some centers' efforts to involve parents. These cases, highlighted in the accompanying box, are suggestive of ways to address the inherent limitations that MSCs confront in this area.

EXAMPLES OF MSC EFFORTS TO INVOLVE PARENTS

- Each semester Center B sends a newsletter to parents recommending ways they can assist their child's study of math and science. Workshops for parents on how to motivate students to pursue math and science careers are held as part of an open house at the end of the summer session.

- Center E has an appointed parent advisory board. The director contacts the parents by phone or mail, asking for their perceptions of students' needs and recommendations for improving curricular content.

- Center M, a local center that merged regular and MSC Upward Bound programs, requires all parents (or parent surrogates) to attend two mandatory meetings each year. Failure to attend results in dropping a student from the program. Two voluntary workshops on financial aid and college admissions also are offered to parents.

V. CONCLUSIONS AND POLICY MATTERS

The Upward Bound math/science centers were created in response to the national goal to increase the representation of disadvantaged youth in math and science college majors and career fields. Currently 81 MSCs across the country attempt to fulfill this mission through programs that serve approximately 3,700 high school students each year. The general design used by MSCs can be characterized as a short-term, high intensity approach to supplemental math and science instruction. The large majority of MSCs offer a six-week summer in residence on campus in which participants engage in concentrated instructional programs emphasizing math and science. For most MSCs, the summer session is the program's centerpiece; typically centers shift to providing quite modest follow-up services to participants during the academic year. For a majority of students, involvement in the center lasts just one year--either because programs are not designed for students to participate multiple years or because students choose not to return.

Six years after the launching of MSCs, it is appropriate to take stock of what lessons can be learned from the centers and to ask questions about their future direction. Should a separate federal grants program for MSCs continue? Should the MSCs continue as currently defined and operated? Should more centers be funded? Should funded centers increase the number of students they serve? Do the instructional approaches and curriculum in the centers provide useful guidance for regular Upward Bound projects to adapt?

Answers to these questions will require more research than is the basis of this report. They will require evaluating MSCs' effectiveness in increasing students' pursuit of math and science at the postsecondary level. Answers also will require viewing MSCs as an alternative Upward Bound strategy and determining their effectiveness in accomplishing the goals of regular Upward Bound--namely, enabling students from disadvantaged backgrounds to enter and complete college. In short,

MSCs provide an opportunity to learn about the effectiveness of precollege strategies used by the centers on two levels: their success with respect to fostering math and science pursuits among disadvantaged youth and to improving the more general postsecondary outcomes of these students.

This report is the product of a preliminary study designed to inform and assess the usefulness of a more ambitious investigation of MSCs' effectiveness. The study sought to provide important background information about MSCs, to examine whether MSC programs differ from regular Upward Bound, to assess whether MSCs offered quality learning opportunities, and to shed light on various issues affecting the functioning of MSCs. This chapter presents conclusions from this effort. Overall, the conclusions suggest that because of their uniqueness and quality learning opportunities, MSCs merit further study to determine how effective their programs in fact are.

A. MSCs CAN SHED LIGHT ON THE EFFECTIVENESS OF ALTERNATIVE PRECOLLEGE APPROACHES

Because the large majority of MSCs deliver a precollege experience different from regular Upward Bound, they can offer insights into the benefits of various features recommended for regular Upward Bound and other precollege programs--features such as small project enrollments and designs requiring students' long term participation. Several important differences are evident when MSCs are compared to regular projects. For example, MSCs typically:

- serve a smaller number of students and are more resource intensive (student-to-staff ratios are one-third those of regular Upward Bound)
- spend $1,000 more per student annually (for a total per student cost of $5,000)
- concentrate their resources on the summer session and have fairly limited contact with students during the school year
- are just one-year programs for over half of the participants
- recruit from a larger geographic area and more varied sources: for example, regular Upward Bound, Talent Search, and target high schools, and

- enroll students who have slightly higher levels of achievement and express interest in math and science fields.

Many of these differences are evident even when MSCs are compared to the one-third of all regular Upward Bound projects that require students to take advanced level math and science courses in addition to a basic core of courses. However, the most fundamental difference between these regular projects that emphasize math and science courses and MSCs as a group probably is the much smaller student to staff ratios that prevail in the MSCs.[1]

Many of the features that differentiate MSCs from regular Upward Bound are the result of ED's evolving policies toward the centers. Originally, ED created only regional centers that served Upward Bound students under the UBMSI. Although MSCs now may serve a single locality, most MSCs have retained the distinguishing focus on a larger geographic area; only a small percentage operate with a purely local focus similar to regular Upward Bound projects. The short-term program involvement that characterizes many students' participation in MSCs also is partially a consequence of federal rules that now permit services to non-Upward Bound students. While this change enlarged the pool of candidates for MSCs, it had the collateral effect of weakening the academic-year services that students' participation in a regular Upward Bound "home" project had promised.

Differences between MSCs and regular Upward Bound will make comparisons of the relative effectiveness of the two programs quite challenging. For example, MSC students differ from regular Upward Bound students not only on the basis of the precollege services they receive, they also differ in terms of their school achievement and interests when they enter the MSC program. These initial differences between students in the two programs must be accounted for when assessing the results of each program. The variety of services that MSC students may or may not receive (for example,

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[1]Case studies that parallel those conducted in MSCs have not been carried out for math/science oriented regular projects.

regular Upward Bound or Talent Search) also adds complexity to accurately assessing the two programs' effects. For example, about one-third of MSC students are likely to have participated in regular Upward Bound for some period of time. Differences in the amount and nature of precollege services received by MSC students must be explicitly identified as part of any study of effectiveness.

B. MSCs MAY OFFER LESSONS ABOUT EFFECTIVE MATH AND SCIENCE INSTRUCTION

The presence of challenging curriculum and of instructional practices that are in line with the widely accepted NCTM and NRC standards for math and science education provide additional support for studying the effectiveness of MSCs. Although available data do not permit comparing MSCs to regular Upward Bound in terms of specific curricula and pedagogical practices, it is possible to judge MSCs against criteria that reflect a number of prevailing views of best practice in the domains of science and math. Among the sound pedagogical practices generally found in MSCs are:

- students' exposure to almost 200 hours of academic work during the course of a summer session, the majority of which focuses on science and math
- coursework that often reflects instructional practices associated with the NCTM and NRC standards: hands-on activities, active teaching, lab work, and group learning
- instructors and tutors with math and science backgrounds; the majority of instructors are secondary school teachers with backgrounds in these subjects and who teach these subjects, while tutors are graduate or undergraduate majors in math or science related fields
- a consistent core of instructional staff who can build upon previously developed curricula and can orient new instructors to the center, and
- an informal curriculum that uses behavioral rules and requirements for personal effort to develop students' self-discipline and academic work ethic.

MSCs also may illuminate effective ways to organize curriculum that is both meaningful to students and addresses the goal of making connections among important concepts. In particular, the

adoption of multi-disciplinary curricula in several MSCs offers a useful contrast to other MSCs' reliance on curricula organized by high school subjects. How much priority to assign to curricula that resemble those in students' high schools is an issue that confronts both MSCs and regular Upward Bound projects. An exploration of the short-term and long-term effects of the two methods of instruction--especially with respect to math and science--would be particularly informative to many precollege programs.

MSCs do not score high on all espoused indicators of best practice. There is only modest participation of postsecondary faculty who conduct scientific research and of professionals who work in applied math and science fields applications. Consequently, MSC students rarely have mentors who are professors at the college or who are professionals working in the areas of math and science. This occurs despite federal rules that call upon centers to arrange for the involvement of such persons in order that students may learn directly from them. MSCs typically comply with these requirements through field trips and an array of speakers who either are faculty members or professionals. MSC staff indicate considerable difficulty in competing for the time of college faculty and professionals to serve as mentors; some staff even express considerable doubt that the payoff is sufficiently large to merit the effort. Unfortunately, the general lack of faculty and professional mentors in centers will make it difficult to learn whether their involvement contributes significantly to short and long-term student outcomes in the areas of math and science.

C. THE QUESTION OF WHETHER MSC ENROLLMENTS SHOULD BE ENLARGED IS NOT LIKELY TO BE RESOLVED EMPIRICALLY

Two key distinguishing characteristics of MSCs are small enrollments and small student-to-staff ratios. These characteristics are a principal reason that MSC per-student costs are one-third higher than those of regular Upward Bound--$5,116 versus $3,839. The question confronting policy makers is whether centers' enrollments and ratios must be this small to be effective. While research can

investigate MSCs' overall effectiveness, the results necessarily will be based on the current enrollment and staffing levels; the limited variation in enrollments and staffing levels across centers will largely preclude uncovering the effect of larger enrollments. Short of a future plan to experiment with different enrollment levels in the centers and examine their results, empirical evidence to indicate optimal enrollment targets for MSCs will not be feasible.

In the absence of empirical evidence, ED faces a dilemma related to enrollment levels. On the one hand, a persuasive case can be made that the federal government should press MSCs to increase enrollments. Currently, average enrollment in the centers falls well beneath the range of 50 to 75 that is specified in ED's regulations. Moreover, the large majority of MSCs report twice as much demand (in terms of applications) for openings as there are spaces available. On the other hand, a reasonable case can be made for allowing the small enrollments to continue (or enlarging them only marginally). The case for continuing small enrollments is partially based on the importance of program stability. Instructors indicate that increased enrollments will alter the nature of the curriculum and pedagogy in the MSCs. In fact, the instructors identify low student-to-staff ratios and the small scale of MSCs as the top reasons that so many of them return to the program each year. Access to additional facilities and extra resources also are factors that MSC staff cite as barriers to increased enrollments. Therefore, efforts to increase center enrollments to any substantial degree are likely to generate some amount of additional cost.

D. MSCs' UNIQUENESS PRESENTS MANAGERIAL CHALLENGES AT THE FEDERAL AND COLLEGE LEVELS

When policy initiatives occur in response to a pressing call for action, they risk losing their sharpness and identity as time passes. Moreover, early in the life of an initiative and at critical points throughout its course, considerable energy must be directed at ensuring that activities supported by the initiative differ from those which have been undertaken before. These two axioms apply to the

Upward Bound Math/Science Initiative. Together, they present problems for managers at the federal and college levels whose challenge is to balance efforts to preserve much of the uniqueness of the centers with efforts to guard against potentially counterproductive boundaries forming around the centers.

1. Federal Management Challenges Related to Upward Bound Program Requirements

Because MSCs exist within the legislative and management framework of the larger Upward Bound program, there is consistent pressure to conform MSCs to requirements governing regular Upward Bound projects. In the longer term, this conformity may compromise MSCs' efforts to pursue the unique instructional programs for which they were established. Requiring MSCs to report identical performance data to that required of regular Upward Bound projects and insisting upon MSCs' offering the full array of subjects that regular projects must offer--in particular, foreign language--represent two areas in which federal conformity appears to be incompatible with the centers' specific mission.

In the case of performance data, many MSCs' shorter periods of contact with students and their initial distance from them during the school year make many of the categories that ED has required in the performance reports quite difficult, if not impossible, to complete. These difficulties may explain the large fraction of centers (well over half) that reported only demographic information on participants or that did not report any data to ED in the 1993-94 Annual Performance Reports. Tracking the outcomes of participants through their college years, a requirement that is just becoming a reality for many centers, is likely to be very difficult, if not impossible, for many MSCs--especially those that by design serve students for a single summer.[2] The current requirements for performance

[2]ED now emphasizes that centers provide one year of follow-up services to all participants. As noted elsewhere in this report, however, these services are often modest and at times are carried out by regular Upward Bound projects.

data indirectly may influence centers to redesign their service delivery system, not for reasons of pursuing worthy strategies but for the purpose of complying with a reporting system. For example, MSCs may decide to abandon single-summer programs or restrict services to a specific geographic area merely to better track students. ED may wish to consider a separate reporting form to alleviate this problem, or to identify the specific categories within the Annual Performance Report that are appropriate to center operations and must be completed; in addition, it would be beneficial to provide the centers with specific guidance about interpreting the categories.

The requirement to offer foreign language poses similar issues of incompatible requirements influencing centers' efforts to pursue a specialized mission. In fact, only half of the case-study MSCs had complied with this requirement at the time visits were conducted. A smattering of instruction in a foreign language during the six-week summer session that is the focal point of MSCs' programs is unlikely to prove very productive for students and draws upon the resources intended to advance other disciplines. Ultimately, ED may wish to consider waiving such subject-matter rules as they apply to MSCs.

2. Managerial Challenges at the College Level Related to MSCs' Uniqueness

At the college level, MSCs' uniqueness poses quite different managerial concerns that in some respects are the reverse of those at the federal level. In the interests of maintaining a distinct program, many MSCs have pursued a level of separation from other precollege programs that may not always be desirable from the perspectives of efficiency, knowledge transfer, and communicating constructive messages to disadvantaged students. Of greatest concern is MSCs' marked separation from the regular Upward Bound project at the host institution. While the vast majority of MSCs are located at colleges where a regular Upward Bound project operates, the two programs typically operate in striking isolation from each other. This occurs despite the fairly frequent sharing of an overarching set of

administrators (often including the project director). The result is that students from the two programs typically have little to no interaction, sharing only dining arrangements and a few social activities.

Although some level of separation between MSCs and regular Upward Bound on the same campus often is warranted--for purposes of specialized instruction and pursuit of unique career interests--the degree to which it currently exists suggests possible inefficiencies (for example, in scheduling speakers and providing college information) and limited cross-fertilization of instructional approaches. Even more worrisome, however, is the potentially damaging message communicated to regular Upward Bound students by a rigid separation of dormitories, program facilities, and educational activities not focused on math and science. The message is potentially damaging because it may communicate the perception that regular Upward Bound lacks academic challenge and is a program in which remedial work is the norm. This message contradicts the emphasis that most regular projects report having adopted in recent years; it also contradicts the growing body of research literature that indicates instructional programs for disadvantaged youth that de-emphasize remedial approaches to instruction are more effective (Moore 1997, Steele undated). College administrators and managers of Upward Bound projects should investigate the extent to which the separateness of the centers explicitly or subtly communicates these messages to students and staff in regular Upward Bound. The success of some centers in blending electives, dormitory space, and field trips may offer ideas for achieving a more productive learning atmosphere for participants in both programs.

E. MSCs' MATH AND SCIENCE CURRICULA ARE POTENTIAL RESOURCES FOR OTHER PRECOLLEGE PROGRAMS

Because MSCs direct their attention in the areas of curriculum development and instructional practices exclusively to the students they serve, most of the curricula and instructional approaches in centers have not been available as resources to the larger community of precollege programs. During the course of visits to MSC, in which curricular materials were reviewed and instruction observed, the

research team was impressed by the challenging content and stimulating nature of many course syllabi and materials that MSC staff had developed. Presently, however, MSC staff have little time and few resources to assist in making these materials available to a broader audience. While the idea of establishing MSCs as resource centers charged with dissemination functions was initially entertained at the inception of the UBMSI, ED set the idea aside for later consideration, deciding instead to focus limited funds on direct student services. Given the curricular resources now present in many MSCs, it may be useful for ED to again consider a plan to facilitate their adaptation by others.

Dissemination of MSC curricula and the pedagogical practices that are linked to those curricula raises several issues. A carefully thought through plan of action is necessary if effective dissemination is to occur. Not all MSCs currently are well-situated or appropriately staffed to become information brokers and to provide training to staff from other programs. Making available additional resources for specific centers with these capabilities or using third parties may be preferable options to imposing additional roles on the centers. Furthermore, a sound plan for dissemination of MSC products must address the fact that not all curricula developed by the centers are of sufficient quality or in a form that is readily accessible to others. Some process for selection and packaging should be included in any dissemination plan ED may develop. Finally, federal program managers may have to overcome possible disincentives for MSCs to share their products. The process of cyclically recompeting the federal grants that support the MSCs may make center staff reluctant to share information and materials that could enable other interested parties to compete successfully against them. A credit in the form of extra points that a center can earn based on its participation in dissemination efforts may help overcome such reluctance.

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APPENDIX A

LIST OF MATH/SCIENCE PRECOLLEGE PROGRAMS FOR DISADVANTAGED YOUTH

APPENDIX A

LIST OF MATH/SCIENCE PRECOLLEGE PROGRAMS FOR DISADVANTAGED YOUTH

Table A.1 describes 28 projects that focus on mathematics and/or science learning among disadvantaged youth. The table provides information on each program in the following areas:

- ***Strategy***: Is the program a school reform project or a targeted intervention effort? What are the most important services it provides?
- ***Objective***: Is the goal of the program to encourage its participants to pursue careers in math- or science-related fields (career focus), to improve its participants math and science preparation (education focus), or some combination of the two?
- ***Student Selectivity***: Are students selected into the program based on academic achievement, interest in math and science, or on other criteria? Does the program select students from specific segments of the disadvantaged population (i.e. Hispanics, rural whites).
- ***Scale and Location***: Is the program local, regional, or national? Urban or rural?
- ***Annual Enrollment***
- ***Grade Level Focus***: Does the program serve elementary, middle, or high school students?
- ***Duration***: Does the program run during the school year, during the summer, or both? What is the length of any summer programs? Are these commuter or residential programs? For how many years do students participate in the program?
- ***Annual Cost per Student***: How much does the program spend on each student, in current dollars?

Table A.1 is based on information from a variety of sources, including the 1992 Department of Education volumes *Reaching For College, Volume 1: Directory of College-School Partnerships* and *Reaching For College, Volume 2: Case Studies of College-School Partnerships,* the 1991 edition of the American Association of Higher Education publication *Linking America's Schools and Colleges:*

Guide to Partnerships and National Directory, the *1996 Directory of Mathematics-based Intervention Projects*, produced by SUMMA (Strengthening Underrepresented Minority Mathematics Achievement), working paper on alternative precollege programs, program brochures, information posted on the Internet, and journal articles. Programs were chosen for review based on the math/science focus of the program and on the depth of information available about the program. While most of the programs targeted minority students, an effort was made to include a broader cross-section of math/science programs in terms of the program goals, strategies, services, and the student selection criteria.[1]

[1]Three of the 28 programs are no longer in operation. In Table A.1, an asterisk follows the names of these programs.

TABLE A.1

LIST OF MATH/SCIENCE PRECOLLEGE PROGRAMS FOR DISADVANTAGED YOUTH

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
1. **Biomedical Sciences Preparation Program (BioPrep)***; University of Alabama, Tuscaloosa	Combination of targeted intervention and school reform: strengthened in-school math and science curriculum for program students; summer program on campus	Career focus: seeks to prepare underrepresented rural students to become health care professionals in rural areas	High-achieving rural students selected; based on academic record and on recommendations	Local; rural	About 2,000 students	High school	4 school years; 4-week residential summer program	$560
2. **Mathematics, Engineering, and Science Achievement (MESA)**; California	Targeted intervention: provides in-school and out-of-school services, including tutoring, academic and career advising, field trips, summer enrichment programs	Career focus: help prepare students for science-related careers	Minority students who are "on track" in math and interested in math and science	Regional; 8 states have MESA programs	23,000 students in CA; 13,000 students in MESA Schools Program (MSP)	Elementary, middle, and high school	Multi-year school-year; optional summer program	$350 (for MSP)
3. **Chicago Area Health and Medical Careers Program (CHAMP)**; Illinois Institute of Technology, Chicago	Targeted intervention: nonresidential summer programs, SAT and MCAT preparation courses	Education and career focus: seeks to prepare students for college, medical school, and medical careers	High-achieving minority students with an interest in the health professions	Local; urban	75 students at each grade level, or about 500 students	Middle (Young Scientists) and high school	6-week summer program for pre-college students	$2,900
4. **Early Outreach Program**; University of Illinois, Chicago	Targeted intervention: school-year Saturday College, preceptorships (for high school students), summer math and chemistry programs (for middle school students), tutoring and counseling	Provide preparation for college preparatory courses and for college; help students to make informed career choices	Minority students who are at or above grade level in all subjects	Local; urban	800 students in grades 7-post-secondary (326 in Saturday College)	Middle and high school	School-year: multi-year, Saturdays; optional summers	$850 (for Saturday College)
5. **The Johns Hopkins University/ Dunbar High School Health Professions Program***; Baltimore, MD	Largely targeted intervention: Summer Scholar Program, internships, tutoring; some school reform: professional development, curriculum	Education and career focus: prepare students for college and health science careers	High-achieving minority students with math and science aptitude	Local; urban	140 students in grades 9-12	High school	Full-year for 4 years; 6-week summer program	$2,000

TABLE A.1 (*continued*)

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
6. **Science and Technology Entry Program (STEP) New Paltz***; State University of New York	Targeted intervention: on-campus Saturday instruction, tutoring, summer math and science enrichment program	Education focus: seeks to encourage math and science study in high school and college	Minority/low-income students who are on or above grade level in math, science	Local; urban	115 students	High school	School-year: 6 Saturdays; 6-week summer residential program	$690
7. **Wright State University Engineering Preparatory Program (Wright STEPP)**; Dayton, OH	Targeted intervention: summer program involves collaboration of local industry and the university; optional weekend program (Wright STEPP Club)	Education focus: seeks to prepare and motivate students to pursue a math or science college major;	Minority students with potential for success in science, math, or engineering	Local; urban	160 students	7th-10th grades	4-week summer program	$625
8. **Science Motivation Program**; Meharry Medical College; Nashville, TN	Targeted intervention: summer research program	Career focus: seeks to redress the shortage of minority cell and molecular biologists	High-achieving African American students; low-income students	Local; urban	12 students	High school	6-week commuter summer program	$1,500
9. **Science and Technology Enrichment Program (STEP)**; University of South Carolina at Aiken	Targeted intervention: Saturday sessions, summer courses on campus, research internships for third-year students	Career and education focus: seeks to encourage students in science and engineering	High-ability minority and female students	Local (serves 3 surround-ing counties)	120 students	High school	4-year program, 2 1-week summer sessions, plus 14 Saturday sessions	$510
10. **EQUITY 2000**; College Board	Systemic school reform: algebra and geometry for all students, professional development; targeted intervention: enrichment for students in need	Education focus: seeks to ensure that all students (especially disadvantaged students) complete algebra and geometry	All students, plus extra support for students in need	National (6 sites across the US)	500,000 students in 700 schools in 14 districts	High school	School-year; summer teacher training	$4 (based on cost of $150,000/ school district)
11. **Detroit Area Pre-College Engineering Program, Inc. (DAPCEP)**; Detroit, MI	School reform and targeted intervention: in-service training, curriculum development, in-school pre-engineering classes, Saturday and summer classes at area universities, engineering-related summer jobs for high school graduates	Career and education focus in science, engineering, and other technical fields	Students with a C-plus GPA and an interest in math and science are selected	Local; urban	400 students in summer program; 6,000 students in 80 schools served overall	Middle and high school	School year and summers	$420

TABLE A.1 (*continued*)

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
12. **Mathematics & Computer Program for the Pima Reservation**; Arizona State University; Tempe, AZ	Targeted intervention: summer program emphasizing hands-on activities and computer literacy	Career focus: designed to increase awareness of careers in math, and show that math can be fun	Native American students of St. Peter's School; not based on ability	Local; Pima reserva-tion	60 students	Grades 3-8; all 8th grade St. Peter's students	4-week summer commuter program	Not Available
13. **Mathematics/ Science PreFreshman Enrichment Program**; Barber-Scotia College; Concord, NC	Targeted intervention: summer program, academic year follow-up, workshops for parents	Education and career focus: increase interest in math and science and influence career choices	Black students from counties with below average and falling CAT math scores	Local; 3 counties in NC	37 students	6th-8th grades	4-week summer commuter program	Not Available
14. **Intensive Summer Science Program**; Bennett College; Greensboro, NC	Targeted intervention: summer program offering courses in math, science, communication skills, programming; field trips	Education and career focus: make math functional and foster computer literacy	Minority and women students; not clear if selection based on ability	National recruit-ment area	150 students	High school	4-week summer residential program	$900
15. **San Luis Valley Program at Colorado College**; The Colorado College; Colorado Springs, CO	Targeted intervention: summer program focusing on math and computer science; families spend one weekend on campus	Education focus: goal is to give students a positive introduction to college life, academically and socially	Hispanic students; not clear if selection based on ability	Rural; regional: CO and Northern NM	18 students	10th and 11th grades	3-week residential summer bridge program	Not available
16. **Mathematics Enrichment Summer Project**; Florida Memorial College; Miami, FL	Targeted intervention: summer program focusing on math enrichment, career awareness, field trips, and school year mentoring	Education focus: provide a firm foundation in math and develop self confidence	High potential underrepresented minority, women, and disabled students	Local: Miami area; urban	40 students	7th and 8th grades	5-week commuter summer program with academic year follow-up	Not available

TABLE A.1 (*continued*)

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
17. **Louisiana Preparatory Program**; Louisiana State University-Shreveport	Targeted intervention: summer program includes math enrichment courses and labs, ACT preparation, and field trips to local industries	Education focus: encourage students to pursue college study, preferably in math or science	"Competent" minority and women students	Local	50 students	7th-9th grades	7-week commuter program for 2 consecutive summers	Not available
18. **Mile High Young Scholars Program**; Metropolitan State College of Denver	Targeted intervention: summer program includes small group experiments, use of computers and graphing calculators, and visits to business and research labs; school year mentoring	Education and career focus: on-campus classes focus on improving math/science skills; field trips focus on career awareness	Minority students; not clear if selection is based on performance	Local; urban	48 students	7th and 8th grades	4-week summer commuter program; school-year mentoring	Not available
19. **Tidewater Young Scholars Program**; Norfolk State University; Norfolk, VA	Targeted intervention: field-work based summer program, focusing on water problems in the area; six follow-up sessions during the academic year	Education and career focus	Minority students; not clear if selection is based on performance	Local; urban	40 students	8th and 9th grades	4-week summer commuter program; school-year follow-up	$600
20. **Occidental Partnership to Increase Mathematics Opportunity (OPTIMO)**; Occidental College; Los Angeles, CA	Targeted intervention	Education focus: provide experience with math and its applications, improve academic success	Predominantly minority students who are skilled and motivated	Local; urban	35 students	8th and 9th grades	4-week summer residential program, plus several school-year activities	$3,400
21. **Pathways of Math & Science of the 21st Century Summer Program**; SUNY, College at Fredonia; Fredonia, NY	Targeted intervention: three module summer enrichment program (Knowing Your Course-work, Knowing Yourself, Knowing Your School System)	Education focus: seeks to interest students in math and science and strengthen their commitment to remain in school	Minority students; not clear if selection is based on performance	Local	50 students	6th-8th grades	4-week summer commuter program	Not available

TABLE A.1 (*continued*)

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
22. **Summer Mathematics Program for Michigan Minority Youth**; Michigan State University; East Lansing, MI	Targeted intervention: comprehensive summer program, including math/science courses, counseling, career exploration, and field trips	Career focus	Black, Hispanic, and Native American students; not clear if selection is based on ability	Regional (MI); urban	80 students	7th-10th grades	1 or 2 years in 6-week summer residential program	Not available
23. **Houston Prefreshman Engineering Program**; University of Houston-Downtown	Targeted intervention: summer program includes study and research in math and science, career awareness, field trips	Career focus	High-ability minority students interested in pursuing science or engineering careers	Local; urban	250 students	7th-9th grades	1-3 year 3-week summer commuter program	Not available
24. **Northeast Science Enrichment Program**; University of Massachusetts; Amherst, MA	Targeted intervention: summer program includes hands-on science and math courses, data collection in Boston Harbor, field trips, and seminars	Career focus: goal is to encourage students to pursue careers in science	Minority students; selected on basis of their applications	Regional (New England, NY); urban	50 students	10th grade	5-week residential summer program	$10,000
25. **Young Scholars Initiative Summer Enrichment Institute**; University of Minnesota; Minneapolis, MN	Targeted intervention: summer program with classroom activities, tours of local businesses, use of interactive visualization software	Career focus	Minorities, women, and economically disadvantaged students interested in math	Local; urban	90 students	6th-8th grades	3-week commuter summer program	$300
26. **Comprehensive Enrichment Program**; American Indian Science and Engineering Society (AISES); Boulder, CO;	Targeted intervention: summer programs with math emphases--specific focus (i.e. geometry, calculus, etc.) varies by site	Education and career focus: seeks to empower youth to make informed college and career choices	High achieving American Indian and Alaskan Native youth with interest in math and science	Nation-wide (sites in 10 states); urban and rural sites	450 students total; about 40 students per site	8th-12th grades	3-6 week residential summer programs	Not available

TABLE A.1 (*continued*)

Name of Project	Strategy	Objective	Student Selectivity	Scale and Location	Annual Enrollment	Grade Level Focus	Duration	Annual Cost per Student
27. **Science and Math Investigative Learning Experiences (SMILE)**; Oregon State University; Corvallis, OR	School reform and targeted intervention: partnership between OSU and 8 rural OR school districts; activities include after school meetings, field trips, and teacher training; also summer bridge program for high school graduates to be attending OSU	Education and career focus: seeks to increase students' knowledge while raising academic and career aspirations	Minority and disadvantaged students	Regional (8 OR school districts); rural	480 students	4th-12th grades	School year plus 3-week camp (middle school); 8-week camp (residential/ commuter, for graduating seniors)	Not available
28. **NASA SHARP PLUS Minority Student Apprenticeship Program**	Targeted intervention: intensive summer research-based apprenticeship program	Career and education focus: increase participation in math/science in all areas	High-achieving students interested in a math/science career	Nation-wide; urban	338 students at 16 institutions	11th-12th grades	8-week summer residential program	$6,200

*Program is no longer in operation. Annual cost per student is in 1995 dollars.

APPENDIX B

CURRICULAR EMPHASIS OF MATH/SCIENCE CENTERS

TABLE B.1

CURRICULAR EMPHASIS OF MATH/SCIENCE CENTERS

Integrated Curriculum			High School Subject-Based Curriculum		
Center	**Description**	**Instructors**	**Center**	**Description**	**Instructors**
A*	Builds on a curriculum pioneered elsewhere (SOAR) that focuses on reasoning and problem-solving skills. Math courses apply concepts from algebra, geometry, trig, calculus, statistics. Science focuses on scientific method, matter, energy, force, motion, and the environment. Composition emphasizes research writing. A 2-3 person project links coursework, and requires a multimedia presentation and written report.	Secondary school teachers; occasional college faculty	E*	College preparatory subjects frame content that ranges from basic to advanced tracks. Students are placed in tracks according to previous math preparation. They take classes in chemistry, biology, physics, computer science, communication skills, composition, and Spanish. Scientific method is a major part of all science classes.	Predominantly high school teachers with some college faculty
B*	Builds on the same reasoning/problem-solving curriculum design used in Center A, with a special emphasis on engineering and computer science. All students take courses in math, engineering, counseling, computer science, robotics, science, and technical writing. At summer's end, students present their engineering project. Students work in labs with faculty/ graduate student mentors for 3 hours each week.	Graduate students; curriculum specialist trains instructors in curriculum	G	Curriculum resembles college prep track in high school. Students are grouped by grade level and prior coursework. They take courses in algebra, trig, calculus, biology, robotics, chemistry, physics, English, SAT test preparation, and counseling (career and academic).	College faculty
C	Marine biology is the shared focus. Students take courses in marine science, technical writing, math/statistics, and personal development/career-college orientation. Topics in marine science unify the experience through field collection of data, analysis in the math/statistics course, and written technical reports. In the third year, students intern with a marine biology professional in the field. Each summer all students complete individual projects.	High school teachers and grad students/college instructors.	K	Curriculum reflects a high school college prep program. Students take 5 courses, which must include composition, Latin, 1 math (algebra II, through calculus), physics, and another science (biology, chemistry, environmental science, organic chemistry). SAT preparation can substitute for a math or science course. Students at advanced levels can pursue independent studies with instructors.	High school teachers

TABLE B.1 (*continued*)

Integrated Curriculum			High School Subject-Based Curriculum		
Center	**Description**	**Instructors**	**Center**	**Description**	**Instructors**
D	Engineering is the shared focus. Students rotate through problem-solving, math, physics, engineering, functions & graphs, technical writing, and personal development classes. Multiple problems and projects are pursued along with an overarching project for display at a museum. Seniors are paired with an engineering mentor.	Predominantly high school teachers ; one professor	M	Curriculum is the same for regular Upward Bound at the college, and parallels college prep track in local school district. Students choose high school credit or not-for-credit courses. For-credit courses include English 9-12 (elective credit only), biology, and prealgebra through calculus. Electives include SAT English, creative writing, and journalism.	Predominantly high school teachers from local district, one college instructor
F*	Aquatic ecology emphasis partially unifies courses. All students must take all courses. Aquatic ecology dominates students' class time and is linked with the Greek/Latin language and art courses. Other classes, which include math, writing and literature, wellness, library skills, and computers, are not linked to ecology. Students are grouped into 4 teams that pursue group projects, including one on aquatic ecology.	Predominantly high school teachers with adjunct faculty roles at college; a few professors	N	Curriculum reinforces and extends college prep subjects of target schools. Courses required of all students include math (algebra II through calculus), science (chemistry, biology, physics), and English 10-12. Students enroll in an additional elective course such as Spanish, marine biology, medical ethics, engineering, art, drama, or SAT math.	High school teachers and graduate students; one former engineer
H	Demonstrates an applied curriculum that integrates high school math and science into courses. Mirrors a college semester in which students take 5 courses. They must take a course on technical presentation, and may choose among courses such as environmental science, genetics, space math, archaeology, and astronomy. All classes involve group projects and presentations.	Graduate students overseen by college faculty			
I*	Research is the unifying focus. One week of workshops in statistics, technical writing, and research design is followed by 5 weeks during which 10 teams of students pursue an intensive research project of their choice. Working with one instructor during this time, groups must collect data, analyze it, write a research paper, and present the results.	Predominantly high school teachers with graduate students/ college instructors			

TABLE B.1 (*continued*)

Integrated Curriculum			High School Subject-Based Curriculum		
Center	**Description**	**Instructors**	**Center**	**Description**	**Instructors**
J*	Partial integration is used. Students take courses in chemistry, physics, natural science, writing, computers, and math. They must complete a science project for display at a museum. Although the entire curriculum is not driven by one theme, instructors often link topics or activities--for example, working with physics data in a math class and writing a research paper on the science project.	Predominantly high school teachers; occasional graduate student			
L	Partial integration is used. Students are grouped by math levels and take thematically oriented science classes such as marine biology, electronics, human physiology, and the ecosystem. English classes include computer use and adopt themes related to the science classes. All students develop a group or individual project as part of the English class. The content in math classes is not intentionally linked with other classes.	Predominantly high school teachers and a few college instructors.			

*Between 0 and 25 percent of students attend multiple summers.