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A Case Study of the Undergraduate Biomedical Research Component of a Federally Funded Minority Student Development Program

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A CASE STUDY OF THE UNDERGRADUATE BIOMEDICAL RESEARCH COMPONENT OF A FEDERALLY FUNDED MINORITY STUDENT DEVELOPMENT PROGRAM

by

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ABSTRACT

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by

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Tremendous growth in the biomedical science workforce has increased the need for trained scientists. The current workforce is severely underrepresented by minority groups, particularly Native Americans. To address this issue, the federal government funded programs that encouraged Native American students to participate in undergraduate biomedical science courses and research. One such program, funded by the National Institutes of Health, is the Minority Student Development Program at Northern Arizona University. Little research has been done on educational programs for minority populations.

The purpose of this study was to identify and describe qualities and characteristics of the undergraduate research component of the federally funded Minority Student Development program from the perspective of Native American student participants. Qualitative case study methods were used to: (a) determine program qualities and

characteristics, (b) develop a knowledge base about the experiences of Native American undergraduate student participants, (c) identify career goals of students to determine if program participation influenced career choices, (d) understand the degree to which a student's cultural background influences career goals, and (e) evaluate the effectiveness of the program. Data were collected through interviews, observations, focus group discussions, informal discussions, questionnaire responses, meeting attendance, and document analysis. In all, 15 students, two program staff members, and eight faculty participated in the study.

Findings from this study include a description of the background and experiences of three subjects: Leroy, Samantha, and Jeremy. While the three were selected for their Native American ethnicity, differences were discovered in their cultural experiences. The three subjects were positive about their program experiences. Career goals of students were greatly influenced by program participation. Findings related to program qualities and characteristics were identified and found to be closely aligned with stated program goals. Suggestions for program improvement included: (a) formalizing the application process, (b) matching student researchers with faculty mentors based on common research interests and personality, (c) faculty mentors closely supervising students to provide support and encouragement, and (d) communicating program expectations for students regarding conference attendance, presenting, and publishing research results.

(105 pages)

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INTRODUCTION

During the past 20 years, there has been tremendous growth in the number of people employed in biomedical science careers (Kelley, Osterweis, & Rubin, 1993). According to estimates in a national study, the biomedical science work force grew from 64,538 in 1981 to over 90,000 in1991 (National Research Council [NRC], 1994). The NRC study (1994) suggests that "advances in research and continuing requirements to address pressing public health concerns will result in the demand for basic biomedical scientists with quite specific research skills" (p. 32).

As the need for biomedical scientists increases, institutions of higher education need to offer programs and courses that will prepare students for future careers (Kyle, 1997). While there are many biomedical disciplines, careers in this field typically require an extensive background in highly specific courses in advanced biology, chemistry, physics, and mathematics (NRC, 1994).

Traditionally, underrepresented minority students have not enrolled in biomedical science courses or pursued careers in these disciplines (Institute of Medicine [IOM], 1994; Murphy & McNair, 1981). Race estimates for biomedical scientists in the NRC report (1994) for 1991 are as follows:

White	88.9%
Black	1.9%
Asian/Pacific Islander	8.9%
Native American/Other	0.2%

(p. 26)

While research continues by the Indian Nations at Risk Task Force and the White House Conference on Indian Education (Cahape, 1993), it is clear that Native American students, as well as other minority students, are underrepresented in biomedical courses and often struggle to succeed (Pavel, 1992).

The federal government is attempting to address this issue by funding programs that encourage underrepresented minority students, specifically Native American students, to participate in undergraduate biomedical science courses and research (IOM, 1994; National Science Foundation [NSF], 1999b; Siebert, 1988).

While research has confirmed that these programs exist, studies do not report on the influence these programs have on career choices made by the Native American undergraduate research participants (DeWitty, 1994; Illman, 1993; Murphy & McNair, 1981; Spencer & Yoder, 1981). Pavel (1992) has suggested "the need for further inquiry into the Native [American] student's higher education experiences" (paragraph 17) related to program participation, college graduation, and career choices.

In 1997, Northern Arizona University (NAU) received funding from the National Institutes of Health (NIH) to begin the Minority Student Development (MSD) program. One goal of the MSD program is to encourage minority students, especially Native American students, in biomedical sciences (Nishikawa, 1997). As an evaluator for the grant, this author was asked to identify MSD program qualities that lead to increased participation by Native Americans (Nishikawa, 1999). As part of the program evaluation, the principal investigators wanted to know how this experience in the undergraduate research component of the MSD program influenced undergraduate Native American

students to pursue careers in biomedical sciences.

Problem Statement

Preliminary information is needed to determine features of the MSD program and how they influenced Native American student participation and success in the program. There was a need to describe program qualitites from the perspective of the student.

Purpose Statement

The purpose of this study was to identify and describe qualities and characteristics of the undergraduate research component of the federally funded Minority Student Development program.

Research Questions

This study was designed to gain further understanding and knowledge about Native American student involvement in biomedical sciences by answering the following questions:

1. What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

2. What implications do expressed qualities and characteristics of MSD have for program improvement?

3. How have career goals of the Native American undergraduate research students changed while participating in the MSD program?

4. What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?

Due to the qualitative case study research design, it was anticipated that other questions could emerge during the inquiry. Therefore, the researcher was open to the possibility of changing the focus of the data collection to better fit the needs of emerging questions (Gall, Borg, & Gall, 1996).

REVIEW OF LITERATURE

The purpose of this literature review was to synthesize findings and substantiate the need for further research in the area of undergraduate research opportunities for minority students in the biomedical sciences. To accomplish this task, the literature review was organized to provide the following information: definition of undergraduate research, historical development of undergraduate research programs, research on the effectiveness of undergraduate research programs, criteria of undergraduate research programs, emergence of the NAU program, and finally, appropriate methodologies for research.

Definition of Undergraduate Research

While the nature of undergraduate research may vary from discipline to discipline, one generally accepted definition given by Halstead (1997b) states that "undergraduate research is an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline" (p. 1390). For the purpose of this study, the term "undergraduate research" is further defined to include experiences where (a) collaboration exists between an undergraduate student and a faculty member, (b) the faculty member acts as a mentor to the student, and (c) the research project could be teacher-initiated or student-initiated.

Historical Development of Undergraduate Research Programs

Looking back at the recent history of science education reform reveals a "flurry of reform activity after the 1957 launch of the USSR's *Sputnik* that awakened America to the fact that it was behind in the 'space race' and galvanized the nation to make changes" (NSF, 1996, p. 9). Many projects geared for inquiry-oriented, active learners were developed to reform science curricula and instructional materials. One such reform movement in undergraduate science education was student participation in undergraduate research programs. Most undergraduate research programs in areas of training and funding failed during the 1960s and 1970s due to a lack of commitment by institutions of higher education. As explained by Gupton (1993), "In 1979, Federal and private funding for research at these schools reached an all time low" (p. 36). NSF (1996) described the funding crisis impact on their programs as follows:

> In 1981, funding for much of the educational effort at NSF, particularly undergraduate education, was reduced drastically and almost fatally. This cycle of intense activity, particularly under an outside threat, real or perceived, followed by complacence, erosion of public interest, and shifting of societal priorities, is not at all uncommon and will likely be repeated .... What is important now, as we look at undergraduate education, is to put in place processes that will sustain the relative excellence of U.S. education in a competitive world. (p. 9)

One agency founded in 1978 was the Council on Undergraduate Research (CUR), a professional organization committed to strengthening undergraduate science education through student research (Halstead, 1997a). Further encouragement came when the National Science Board issued the Neal Report in 1986. This report recommended a

substantial increase in expenditures by NSF for undergraduate research programs (NSF, 1996). With financial support from NSF and other sources, institutions of higher education expanded the number of undergraduate research programs in scientific fields. In 1997, the Council on Undergraduate Research reported a membership growth to over 3,500 scientific faculty in more than 650 colleges and universities (Halstead, 1997a).

Research on the Effectiveness of Undergraduate Research Programs

The review of literature on characteristics of undergraduate research programs was based on articles obtained by searching the ERIC database using combinations of the following descriptors: undergraduate study, student research, undergraduate students, federal programs, and science.

The 18 collected articles include: four primary research articles (Goodlad, 1998; Sabatini, 1997; Spencer & Yoder, 1981; Yoder & Spencer, 1987), four federal reports (Halstead, 1997a, 1997b; NSF, 1989, 1999a), four position statements or opinion articles based on experiences in developing undergraduate research programs (CUR, 1999; Howard Hughes Medical Institute, 1997; Lanza, 1988; Pladziewicz, 1984), and six articles describing undergraduate research programs (DeWitty, 1994; Houck, 1988; Illman, 1993; Lanza & Smith, 1988; Rettig, Bunker, & Ruchti, 1990; Siebert, 1988). The literature sources used for this portion of the review are summarized in Table 1.

Based on analysis of the literature, categories were developed to identify effectiveness of undergraduate research programs in three areas: (a) benefit to students,

Table 1

Literature Review Sources for Effectiveness of Undergraduate Research Programs

Type of article	No.	Percentage	Type of article	No.	Percentage
Position statement	4	22.2	Research	4	22.2
Project description	6	33.3	Federal report	4	22.2

(b) benefit to faculty mentors, and (c) benefit to the field of science. Articles were then coded based on multiple categories of effectiveness. During the coding process, categories were refined several times. The results of the coding process were tabulated by category for comparison and analysis (Gall et al., 1996). Based on analysis of the coding, characteristics of effective undergraduate research programs included the following.

Benefits to Students

1. The hands-on approach, where students learned by doing, was an effective method for discovery learning.

2. Undergraduate research allowed for understanding of science and research methodology unrivaled by any other aspect of curriculum.

3. Research experiences helped students develop close relationships with faculty mentors.

4. Students were given the opportunity to present and publish research results.

5. Students developed skills in creative problem solving.

6. Research experiences boosted self-confidence in science and helped students learn the value of hard work and perseverance.

Benefits to Faculty Mentors

1. Insight and enthusiasm were gained from working with students.

2. Faculty mentors tended to publish more and received more grant funding than their colleagues.

3. Students provided faculty mentors with extra help for research.

4. Departments tended to allow faculty mentors more time to try new ideas or experiments.

5. Faculty mentors tended to change their teaching style.

Benefits to the Field of Science

1. Undergraduate research programs increased the nation's supply of scientists by preparing undergraduate students for graduate school or careers in science.

2. Developing undergraduate research programs was an effective strategy for attracting and retraining students in scientific fields of study.

3. Programs with undergraduate science research had potential for increasing participation by minorities and women.

4. There was value in meaningful application of science principles.

5. Research results had intrinsic value.

Summary

The literature provides ample characteristics of effective undergraduate research programs. As stated by NSF (1999a), "Active research experience is one of the most effective techniques for attracting talented undergraduates to and retaining them in

careers in mathematics, science, and engineering" (paragraph 1). Perhaps the literature is best summed up by the following quote from Halstead (1997a):

> Undergraduate research is increasingly valued as a critical component of an undergraduate science education. Science is the process of personal discovery through experimentation and critical, creative thinking. Students working side-by-side with faculty mentors learn not only from their own discoveries, but from close observation and guidance of their mentors, typically insatiable learners themselves. Essential to effective science teaching is this process of student/faculty immersion in a culture of learning. (p. 148)

Table 2 summarizes characteristics of effective undergraduate research programs, including the number of articles citing each characteristic of effectiveness. Literature

Table 2

Summary of Characteristics of Effectiveness of Undergraduate Research Programs

Characteristic of effectiveness	No. of articles
Benefit to students:	
• discovery learning through hands-on approach	6
• greater understanding of science and research methodology	6
• close relationships developed with faculty mentors	3
• opportunity to present and publish research results	3
• skills developed in creative problem solving	3
• boost self-confidence in science	3
Benefit to faculty mentors:	
• insight and enthusiasm gained from working with students	3
• increase in publications and grant funding	3
• students provide research help	1
• departments allow more time for research	1
• faculty tend to change their teaching style	1
Benefit to the field of science:	
• increase in the nation's supply of scientists	8
• students attracted and retained in science fields	5
• increased participation by females and minorities	3
• meaningful applications of science	2
• intrinsic value of the research results	1

programs. The next step is to explore qualities and characteristics of exemplary reviewed in this section clearly purports positive effects of undergraduate research undergraduate research programs.

Criteria of Undergraduate Research Programs

Sixteen articles collected on criteria include: two primary research articles (Hammick & Acker, 1998; Spencer & Yoder, 1981), two federal reports (Halstead, 1997b; NSF, 1999b), eight position statements or opinion articles based on experiences in developing undergraduate research programs (Beer, 1995; Belliveau & O'Leary, 1983; CUR, 1999; Hansch & Smith, 1984; Howard Hughes Medical Institute, 1997; Lanza, 1988; Pladziewicz, 1984; Spector, 1993), and four articles describing undergraduate research programs (Chan & Lee, 1991; Gentile, 1988; Hogg, 1988; Williams & Powell, 1988). The sources used for this portion of the review are summarized in Table 3.

Based on analysis of the literature, qualities and characteristics of exemplary undergraduate research programs were identified in eight areas: (a) faculty responsibility, (b) expectations for students, (c) style of mentoring, (d) financial support, (e) scheduling, (f) selection of research topic, (g) presentation of research results, and (h) other.

Table 3

Literature Review Sources for Criteria of Undergraduate Research Programs

Type of article	No.	Percentage	Type of article	No.	Percentage
Position statement	8	50	Research	2	12.5
Project description	4	25	Federal report	2	12.5

Qualitites or characteristics of exemplary undergraduate research programs in the literature include the following.

Faculty Responsibility

Faculty mentors were knowledgeable leaders in their scientific field. In the beginning stages of the research, faculty mentors thoroughly planned their research project. Students were taught research methodology and proper use of lab equipment. Faculty mentors met with students on a regular basis to monitor progress and provide encouragement, support, and motivation. Students were given both direction and freedom as they continued working on the research project. Faculty mentors trained students to review current literature in their scientific field and provided student tours of research facilities.

Selection of the Research Topic

Research topics were selected based on a belief that the research was important and interesting to students, and of interest to faculty mentors. Topics were chosen because they were original ideas, adaptable to the capabilities of undergraduate students, and encouraged exploration. Topics were selected because of financial support and the availability of necessary lab equipment.

Financial Support

Students were paid for participation in the research program. Faculty mentors received a stipend or salary increase, plus additional funds for the purchase of lab

equipment or supplies.

Style of Mentoring

Faculty mentors worked one-on-one with students, or in small groups. For instance, three faculty mentors were responsible for supervising 10 research students. The students and faculty mentors were matched according to common interests in research topics. A close, working relationship existed between faculty mentors and students.

Expectations for Students

Research results were to be published and presented by students. They were expected to work hard and be persistent, but were allowed to make progress at their own speed. Students were encouraged to be creative and were free to make mistakes. Students from underrepresented groups were encouraged to participate. Research students were to prepare for graduate school.

Scheduling

Lab work was scheduled for longer periods of time, such as 3 hours or more. Students were allowed sufficient time for the application process for admittance to the program. Research experience was ideally scheduled during the junior or senior year in college. Lab work was scheduled in a research intensive setting, possibly in a facility off-campus.

Other

The multidisciplinary involvement of various departments on campus was

preferred. There was benefit in raising awareness of research programs, both in the local community and the national scientific community.

Summary of Literature on Exemplary Undergraduate Research Programs

Table 4 summarizes qualitites or characteristics of exemplary undergraduate research programs, including the number of articles citing each criteria.

Table 4

Summary of Qualities of Exemplary Undergraduate Research Programs

Quality or characteristic	No. of articles
Faculty responsibility:	
• meet students on a regular basis	4
• encourage and motivate students	3
• teach research methodology	3
• train students to review current literature	2
• give students direction and freedom	2
• be a knowledgeable leader in a scientific field	2
• train students to use lab equipment	1
• thoroughly plan the research project	1
• provide student tours of research facilities	1
Research topic selection:	
• based on student belief that research is important	3
• realistic adaptation to undergraduate students	3
• based on an original idea	3
• based on student interest	3
• based of interest of faculty mentor	1
• encourages student exploration	1
• based on financial support	1
• based on availability of lab equipment	1
Financial support:	
• students are paid for participation	9
• salary increase for faculty mentors	4
• money spent to purchase equipment	2

(table continues)

Quality or characteristic	No. of articles
Style of mentoring:	
• one faculty mentor for each student	2
• three faculty mentors for ten students	2
• student-faculty mentor matched on research interest	2
• success based on student-faculty mentor relationship	2
Expectations for students:	
• present and publish research results	8
• work hard but free to make mistakes	3
• progress at own speed	1
• minorities encouraged to participate	1
• prepare for graduate school	1
Scheduling:	
• longer periods of time for lab work (>3 hours)	2
• sufficient time for the application process	2
• start research by junior or senior year of college	2
• finding a research intensive setting	1
Other:	
• involve other departments on campus	4
• raise community awareness	1

Thirty-five characteristics of exemplary undergraduate research programs were identified in the reviewed literature. These characteristics were used to develop instruments and organize the interpretation of results for this study.

Overall, characteristics in areas of faculty responsibility, research topic selection, and financial support were cited the most. Individual characteristics with the highest number of citations in the literature included: (a) students received financial support for participation, (b) students were expected to present and publish their research results, (c) faculty mentors met with students on a regular basis, (d) faculty received financial compensation for supervision, and (e) programs involved a variety of departments across campus in research opportunities for undergraduate students.

Based on the extensive list of characteristics found in the literature, it is important to make the following observations:

1. A small percentage of articles (12.5%) were research based.

2. Most articles (50%) were based on opinions of those with experience in undergraduate research program development.

3. Some disagreement existed among authors as differing advice was given in the areas of mentoring style and scheduling.

4. There were no reviewed articles that presented ideas from the students' perspective.

5. Articles in this review had an average of five characteristics of exemplary programs per article. Therefore, it was not expected that one undergraduate research program could incorporate all qualities and characteristics. Rather, program developers were to carefully create programs to meet the diverse needs of the involved students and faculty.

Emergence of the Northern Arizona University Program

Experts at NAU felt the need to develop a program to enhance the academic experience of Native American undergraduate students in the biomedical fields. It is well documented that Native American students have lower retention and graduation rates than majority students, as demonstrated by the following NAU statistics:

> For students who enrolled in NAU between 1987 and 1994, the retention rate 1 year after admission was only 55.4% for Native American students, whereas 70.3% of White students returned to NAU after the first year. By

> 5 years after admission, the graduation rate for Native American students was less that one third that of the White students who have completed degrees. (Nishikawa, 1997, p. 72)

Nishikawa (1997) believed in undergraduate research as a strategy for academic enrichment "to improve the academic performance of students, as well as to provide individual mentoring by excellent research faculty" (p. 77). Research opportunities were seen as opportunities for students to develop self-confidence, creativity, problem solving skills, a deeper understanding of science, and skills necessary to continue on to graduate school or a career in science.

In developing an undergraduate research program, NAU faculty incorporated the following characteristics: financial support for students through a stipend, tuition waivers, travel expenses to present research at a professional conference; extra pay for faculty mentors; faculty mentors assigned to work one-on-one to motivate and train students; and student selection based on interest in biomedical science and willingness to learn research methodology (Nishikawa, 1997).

The NAU model incorporates qualities or characteristics of effective and exemplary undergraduate research programs. No reference was made to the belief stated in the literature that a hands-on approach of students learning by doing was an effective method for discovery learning. It is possible that NAU experts agree with this belief yet omitted it from their program design.

Appropriate Methodologies for Research

Further research was needed to describe identifying characteristics of

undergraduate research programs to determine specific characteristics or features that lead to career choices in biomedical science for Native American student participants (Hartung, 1995). An appropriate approach for such research is the Pure Qualitative Strategy described by Patton (1987).

When Patton's model is used to describe a program in great depth, a qualitative case study is an appropriate methodology. Case studies are used as a "method of learning about a complex instance through extensive description and contextual analysis" (Davey, 1991, paragraph 10). According to Patton (1987), case studies are particularly valuable when

> ... one needs to understand some particular problem or situation in great depth, and where one can identify cases rich in information--rich in the sense that a great deal can be learned from a few exemplars of the phenomenon in question. (p. 19)

Patton's (1987) Pure Qualitative Strategy includes a combination of naturalistic inquiry, qualitative data collection, and content analysis. These strategies are particularly well suited for identifying specific characteristics of emerging programs. According to Patton's model, program participants selected for research are interviewed and observed at various times during the course of the program. The data are then analyzed to "find out what patterns of experience participants bring to the program, what patterns characterize their participation in the program, and what patterns of change are reported and observed among participants" (p. 66).

PURPOSE AND OBJECTIVES

Statement of General Purpose

This research was a case study of the undergraduate research component of the MSD program at NAU. The purpose of this research was to develop a knowledge base about the experiences of Native American students who were involved in the program. Of particular interest was the influence of participation in the MSD undergraduate research program on their career goals.

List of Specific Objectives

Six objectives were used to identify intended outcomes or accomplishments of this research. Each objective, or group of objectives, is followed by the corresponding research question.

Objective 1: To determine the qualities and characteristics of the MSD program, particularly the undergraduate research component.

Objective 2: To understand the MSD program from the Native American students' perspective.

Objective 3: To observe Native American students engaged in their MSD undergraduate research assignment.

Research Question 1: What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

Objective 4: To interpret expressed MSD program qualities and evaluate the

effectiveness of program characteristics as requested by the principal investigators.

Research Question 2: What implications do expressed qualities and characteristics of MSD have for program improvement?

Objective 5: To identify career goals of MSD Native American students over time to determine if participation in the MSD program influences career choices.

Research Question 3: How have career goals of the Native American undergraduate research students changed while participating in the MSD program?

Objective 6: To understand the cultural background of the MSD Native American students.

Research Question 4: What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?

CONTEXT

Native Americans at Northern Arizona University

Northern Arizona University (NAU) is located in Flagstaff, Arizona on the Colorado Plateau in the rural Four Corners area of the southwestern United States. The mission statement of the University is summed up in the following five goals:

- To be recognized as a premier undergraduate residential campus in the western region of the United States,
- To become recognized as a leader in partnerships with community colleges and K-12 education,
- To become recognized as a national leader in the use of technology for distance learning,
- *To be a national leader in providing educational opportunities for Native American students, in providing service to Native American tribes, and in research in contemporary Native American policy issues,* [italics added]
- To be recognized nationally and internationally for research and graduate programs that build from our regional base on the Colorado Plateau and our work with communities throughout rural Arizona. (Northern Arizona University, 1999a)

As evidenced in these goals, NAU has a special mission to provide educational opportunities for underrepresented minorities, specifically Native American students. According to the MSD proposal:

> As of Fall Semester 1996, Northern Arizona University (NAU) had the fourth largest enrollment of Native American students among four-year institutions in the United States .... Of a total enrollment of 19,605 students in Fall 1996, 1198 were Native Americans representing 37 different tribes. (Nishikawa, 1997, p. 72)

Biomedical Science Courses and Careers

The MSD program includes minority students in health preprofessional programs enrolled in biomedical science courses at NAU. While biomedical science included a wide range of courses, the MSD program identified entry-level courses that were required for all majors in the biomedical sciences. These courses included Plant Biology (BIO 124), Animal Biology (BIO 190), Biology of Microorganisms (BIO 220), Human Anatomy and Physiology (BIO 201 and 202), Genetics (BIO 240), Intermediate Algebra (MAT 102), College Algebra and Trigonometry (MAT 112), General Chemistry I and II (CHM 151 and 152), Organic Chemistry (CHM 235 and 238), and Critical Reading and Writing (ENG 105; Nishikawa, 1997). The goal of these courses was to prepare students for necessary upper division coursework in their respective majors. The ultimate goal of the program was to prepare students for graduate programs, medical school, or a variety of health professions. Typical career choices in biomedical science professions included: medicine, dentistry, osteopathic medicine, optometry, podiatry, veterinary, physician assistant, pharmacy, occupational therapy, chiropractic, public health, and EMT/paramedic (NRC, 1994; Northern Arizona University, 1999b).

RESEARCH DESIGN

This research study was designed using a qualitative case study model developed by Patton (1987), including naturalistic inquiry, qualitative data collection, and content analysis. Focus groups, individual interviews, and observations were used as methods of qualitative data collection. Observations were also used for naturalistic inquiry, thereby allowing the researcher to "focus on capturing program processes, documenting variations, and exploring important individual differences between various participants' experiences and outcomes" (Patton, 1987, p. 14). Content analysis of the qualitative data (observation field notes, interview and focus group notes) involved "identifying coherent and important examples, themes, and patterns in the data" (p. 149).

As defined by Gall et al. (1996), a case study is intended to be an "in-depth study of instances of a phenomenon in its natural context and from the perspective of the participants involved in the phenomenon" (p. 545). In this case, the phenomenon was Native American student participation in the MSD program, the context was the NAU biomedical science program, and the informants were the students and faculty involved in the MSD program.

Patton's case study model was an appropriate tool as it allowed the researcher (a) to meet the goals and objectives of the proposed research, (b) to assist in MSD program evaluation, and (c) to provide a detailed description of the MSD program that could be shared with other colleges or universities trying to incorporate similar programs.

Subject Selection

Subjects selected for the in-depth case study were Native American participants in the undergraduate research component of the MSD program. To be eligible for the MSD program, undergraduate students must have indicated an interest in biomedical science and been enrolled in at least one MSD course. To become an undergraduate researcher, students must have applied and been accepted into the program. Once accepted, they were paid by the MSD grant to participate in the program. Of the approximately 20 minority students involved in the program, three Native Americans were chosen for the in-depth study. The student selection was based on recommendations of the principal investigator of the grant, and feedback obtained from student focus group data. According to Patton (1987), this type of selection is called "typical case sampling" as program staff or knowledgeable participants were used to help identify "average" or "typical" subjects for the sample (p. 54).

Data and Instrumentation

To conduct the case study, the researcher traveled to NAU for 2 to 3 days per month during the 1999 summer semester. During that time, subjects were interviewed and observed in their research assignment. Further insight into the background and experiences of the three student researchers was obtained through access to university documents pertaining to each subject, such as class schedules, transcripts, research assignments, and their applications for admittance into the program.

Three data collection methods (focus group discussions, interviews, and observations) are described along with the research questions they address.

Focus Group Discussions

MSD research students were invited to attend a one and one half hour focus group discussion. Of the 20 students currently enrolled in the program, six students participated: two Native Americans, and four Hispanics. The purpose of the focus group discussion was to stimulate interaction among the students, to discover their feelings, beliefs, and perceptions of specific qualities and characteristics of the MSD program (Gall et al., 1996). With this goal in mind, focus group questions, or prompts, were used to probe students about various aspects of the MSD program. Focus group data were captured by note taking and tape recording. Focus group questions are included in Appendix A.

Focus group data were used to answer the following research question:

1. What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

2. What implications do expressed qualities and characteristics of MSD have for program improvement?

3. How have career goals of the Native American undergraduate research students changed while participating in the MSD program?

4. What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?

Interviews

The researcher developed open-ended interview questions based on the goals and objectives of the study. The questions developed for MSD faculty and staff are included in Appendix B. The outline of questions developed for the three subjects are included in Appendix C. The principal investigator of the MSD grant had the opportunity to review the questions to check their consistency with MSD program criteria (Kirk & Miller, 1986). Questions developed for the interviews and focus group discussions were submitted for review to the Institutional Review Boards of both NAU and Utah State University.

The selected interview model was the "interview guide approach" developed by Patton (1987). With this format, the researcher prepares questions or topics to be explored with the respondent, without regard to the order, and allows for individual perspectives and experiences to emerge during the questioning process. If a response requires further clarification, another question is asked to elicit further information.

Over the course of this study, the researcher conducted three interviews with each of the three students selected for the in-depth questioning and observation. The decision to end the interview data collection was based on Lincoln and Guba's (1985) four criteria: the exhaustion of data sources, the saturation of categories, the emergence of regularities, and overextension of new information. The researcher also interviewed the faculty research mentor assigned to each of the three students. Interviews were scheduled for 1 hour, but actual length ranged from 40 minutes to 2 hours. Interview data was captured by tape recorder, with notes also being taken for backup purposes.

Interview data were used to answer the following research questions:

1. What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

2. What implications do expressed qualities and characteristics of MSD have for program improvement?

3. How have career goals of the Native American undergraduate research students changed while participating in the MSD program?

4. What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?

Observations

To better understand the MSD program, the researcher planned to observe the three students in their research setting. Observations were scheduled for 2 hours with the understanding that they were to continue until "no new patterns emerge, what you are observing/hearing you have heard before" (Lancy, 1993, p. 242). Actual observation times varied due to the nature of the research and the time constraints of the student researchers. One observation was 30 minutes and another was two and one half hours. The third student was not observed in the research setting as his work takes place on the reservation. Although the researcher for this study was willing to travel to the reservation, the student researcher was concerned about compromising his work by bringing visitors to observe his data collection.

The researcher used field notes to record observation data, using descriptive

observational variables to depict activities that took place during the MSD research experience (Gall et al., 1996).

Observation data were used to answer the following research question:

1. What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

2. What implications do expressed qualities and characteristics of MSD have for program improvement?

Analysis

Interpretational analysis methods were used to examine the case study data "to find constructs, themes, and patterns that [could] ... be used to describe and explain the phenomenon being studied" (Gall et al., 1996, p. 562). The first step in the interpretational analysis was to compile the case study data into a computer file. Tape recordings for each interview and focus group, along with observation field notes, were transcribed into computer files and segmented into units. An example of one unit would be an interview question and the corresponding response.

The second step in the interpretational analysis was to create categories. Categories developed by the researcher were based on the goals and objectives of the MSD program, feedback from the principal investigator, experiences gained during the evaluation process, and studying the data (Miles & Huberman, 1984). The third step was to use the categories to code the transcribed data. During the coding process, the category system was continually revised and refined as needed to best represent the meaning of the

data. As new categories emerged or were modified, it was necessary to recode some of the segments (Gall et al., 1996). The fourth step was to group segments together by category. With all segments grouped together by their coded category, segments within and across categories were compared to verify the sensibility of the categories. Glaser and Strauss (1967) coined the term "constant comparison" to refer to this continual process of refinement. This process ended when "theoretical saturation" occurred and the researcher was comfortable that no additional categories were needed (Gall et al., 1996).

The final step in the interpretational analysis was to draw conclusions based on the discovery of themes, patterns, or constructs in the transcribed data (Miles & Huberman, 1984).

The interpretational analysis process included coding checks and refinement of categories to check the validity and reliability of the case study findings. Validity and reliability of case study findings were further tested by triangulation, member checks, and an audit trail.

Triangulation

According to Gall et al. (1996), "Triangulation helps to eliminate biases that might result from relying exclusively on any one data-collection method, source, analyst, or theory" (p. 574). In this case, multiple data-collection sources (focus group discussions, interviews, and observations) were used to verify subject responses (Lancy, 1993; Patton, 1987). For each subject, responses to interview questions were compared to corresponding items on a questionnaire. In the few cases where contradicting responses

were discovered, followup questions were asked to clarify the conflicting data. The questionnaire is included in Appendix D.

Another tactic used for triangulation was interviewing members of the MSD staff and faculty. This strategy proved useful in discovering a misunderstanding regarding benefits of MSD participation. In one focus group, a student mentioned that he appreciated getting free textbooks through the MSD program. Other students were surprised and upset that they were not receiving the same benefit. In an interview with an MSD staff member, it was revealed that MSD students do not receive free textbooks. The one student who was receiving free textbooks was getting them through a separate grant.

Member Checking

Similarly, subjects were asked to "review statements made in the researcher's report for accuracy and completeness" (Gall et al., 1996, p. 575). Three activities related to member checking were used in this study. The first activity involved giving the transcribed interview notes to the subjects to read and verify for accuracy. For example, the first interview with a particular subject was transcribed and brought to the second interview with the subject. However, the transcription was not shown to the subject until the end of the second interview in an attempt to control for possible bias in responses from reviewing previous interview responses. The subject was then given time to read and comment on the accuracy of the transcription. Overall, about 10 corrections or clarifications were made during this process.

The second member-checking activity related to the tape recordings. In several

instances, the tape recorded interviews had words or phrases that were impossible to decipher. In these cases, subjects were asked to supply the missing information.

The third member-checking activity related to reviewing the final report of the research. The three subjects participating in the in-depth case study were given the opportunity to read and respond to the written draft of this research.

Member-checking strategies, such as the three activities specified here, are especially helpful in accurately describing a phenomenon from the subjects' perspective (Lincoln & Guba, 1985).

Audit Trail

An audit trail includes organizing qualitative data for analysis (Patton, 1987) and "documenting the materials and procedures used in each phase of the study" (Gall et al., 1996, p. 754). Records were kept to document the schedule of events and procedures used in the data collection process. This "chain of evidence" was designed to make "clear, meaningful links between research questions, raw data, and findings" (Gall et al., 1996, p. 576).

Summary

The purpose of this study was to provide feedback to MSD principal investigators about qualities and characteristics of the undergraduate research component of the federally funded program. Using qualitative case study methods, this study described the MSD program in great depth from the perspective of Native American student

participants. Patton (1987) described the value of using case study methodology in evaluation as follows:

> Evaluation reports based on qualitative methods will include a great deal of pure description of the program and experiences of people in the program. The purpose of the description is to let the reader know what happened in the program, what it was like from the participants' point of view to be in the program, and what particular events or activities in the program are like. (p. 147)

Interpretations and recommendations based on research findings were limited to qualitites and characteristics of the MSD program. No attempt was made to generalize results across other programs. Generalizability enhances validity and was therefore seen as strengthening quantitative research (Gall et al., 1996). However, Patton (1987) presented an opposite view for evaluators using qualitative methods: "While scientists search for universal laws and generalizations across time and space, evaluators tend to focus on providing useful information that is fairly specific to one or a few programs" (p. 167).

Therefore, by accurately portraying aspects of the MSD program from the students' perspective, this research was designed to provide understanding as an appropriate equivalent for validity (Wolcott, 1990), as understanding gives researchers "the power to make experiences intelligible" (p. 146).

FINDINGS

This case study was conducted to learn more about the experiences of Native American students in the undergraduate research component of the MSD program at NAU. The researcher gained an understanding of the program through a focus group, interviews, observations, responses to a questionnaire, informal discussions, various documents, faculty meetings, and a symposium.

A focus group discussion with six students in the MSD program helped the researcher discover student perceptions about the program and identify three Native American undergraduate students for the in-depth study. None of the six students were selected for the in-depth study as they were either Hispanic or had scheduling conflicts.

Formal interviews were conducted to collect data from students, faculty and staff related to program characteristics, career goals of students, and cultural influences. Informants included three students from the focus group, three students from the in-depth study, eight MSD faculty, and two MSD staff. To better understand the MSD program, two of the three students in the in-depth study were observed in their research setting.

A questionnaire was used to verify subject responses to interview questions about qualities and characteristics of the MSD program. Questionnaire responses were obtained from three students from the focus group and three students from the in-depth study.

Informal discussions about MSD program characteristics took place with 10 MSD undergraduate and graduate students from a variety of ethnic groups, mainly Native American, Hispanic, African American, and Pacific Islander.

Documents were collected pertaining to the biomedical program at NAU, the MSD students, and the MSD program. The researcher gained additional insight by attending monthly professional development meetings for the MSD faculty, and the MSD 99 Science Symposium. A listing of symposium presentations is included in Appendix E.

Data collection occurred over a 3-month period during NAU's summer semester, with the researcher traveling to Flagstaff once a month for 2 to 3 days. During the 9-month period prior to data collection, the researcher made six trips to NAU to assist in the evaluation of the MSD program. In all, 15 students, two MSD staff, and eight faculty participated in the study.

The inquiry was guided by the research questions:

1. What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?

2. What implications do expressed qualities and characteristics of MSD have for program improvement?

3. How have career goals of the Native American undergraduate research students changed while participating in the MSD program?

4. What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?

The findings reported in this section are the result of interpretational analysis through which themes and patterns describing the phenomenon and focus of the study were identified. Each of the three research questions was used as a base category for coding the data. Data relating to Questions 1 and 2 were coded in the "MSD program"

category, Question 3 was answered by data coded as "career goals", and data relevant to Question 4 were coded in the "Native American culture" category. Each of these categories had subsections relating to different constructs and themes in each category. Content analysis was used to identify examples, patterns, and themes in the data.

The research findings for the present study are presented in three parts. The first part describes each of the three subjects selected for the in-depth case study and presents findings related to the MSD program, career goals, and Native American culture (research questions 1, 3, and 4). Each subject description begins with an introduction, including information about academic status, career goals, and participation in the MSD program. After the introduction, findings are presented in the following areas: family background, education, interest in biomedical science, cultural beliefs or issues, MSD program experiences, and suggestions for improvement of the MSD program. Data used in part one of the findings came from interviews, observations, a questionnaire, a symposium, and various documents.

The second part includes findings from the perspective of MSD students, faculty, and staff related to qualities and characteristics of the MSD program (research question 1). Data used in part two of the findings came from interviews, a focus group, informal discussions, a questionnaire, faculty meetings, a symposium, and various documents.

The third part includes findings from the perspective of other MSD student participants, and MSD faculty and staff related to career goals of the Native American undergraduate research students (research question 3). Data used in part three of the findings came from interviews, a focus group, informal discussions, a questionnaire,

faculty meetings, a symposium, and various documents.

Description of Subject 1: Leroy

Leroy, a senior at NAU working on a bachelor of science degree in biology, has been in the MSD undergraduate research program for 1 year. His ultimate goal is to go to medical school and then return to the reservation to serve the needs of the Navajo people as a medical doctor. In the MSD program, his research has been in the area of lung disease and pulmonary health of Navajo and Hopi children and adults. Rather than working in a lab on campus, Leroy travels to the reservation to conduct pulmonary function tests on Native Americans in an attempt to develop pulmonary function nomograms, or tools for diagnosing lung disease.

Family Background

Leroy was born and raised on a Navajo reservation in northeastern Arizona and is proud to say that he is 100% Navajo. He prefers to be called "American Indian" rather than "Native American" because the definition of Native American includes almost everybody whereas he believes the term Indian is more "politically correct."
As a young child, his parents divorced and he and his three siblings were raised by their mother. His father, a Medicine Man on the reservation, never supported his ex-wife and children and now has another family of his own.

For Leroy, life on the reservation was focused on developing and maintaining strong family ties with his mother, siblings, grandparents, and other relatives. Being

raised by a single parent was difficult as the Navajo culture emphasized family unity and the notion that the needs of the family come before the needs and wants of the individual. Even though he was raised without a father in the home, Leroy believes that his relationship with his mother and siblings was stronger than that of his friends in two-parent households.

As a family living in a simple environment without electricity or running water, much of their time was devoted to tasks associated with providing food, shelter, warmth, and other necessities of life. Growing up without a car meant relying on relatives for transportation needs.

Education

Leroy attended a reservation school from kindergarten through seventh grade. Afternoons and evenings were spent doing chores around the house, such as chopping wood for the wood stove or bringing in water, and caring for the sheep, cattle, and horses. According to Leroy, they were "very, very poor but happy."

Leroy and his brother were faced with a difficult challenge when they finished the schooling available to them on the reservation and decided to continue their education. To continue school meant going 100 miles away from home and living in a dormitory for American Indians provided by the Bureau of Indian Affairs. They would ride to the school with relatives on Monday mornings and stay until Friday afternoon when they could return to the reservation for the weekend. It was very lonely and sad for them to be away from their home and family. They found it especially challenging as their culture

seemed to tolerate, rather than value or appreciate, their pursuit of an education. While their mother preferred they stay home and work, she would say, "If you want to do that [go away to continue school], just do it."

After high school graduation, Leroy worked full-time and had no plans or goals for his future. As he relates, "College never came across my mind ... I just worked. It was like the value of education was never inside my home. It was never talked about as my mom only went to the third or fourth grade." It was his employer who persuaded him to save money and go to college. A year later, he left home and started classes at a 2-year community college near Phoenix. After completing 1 year at the community college, he transferred closer to home to pursue a bachelor of science degree in biology at NAU.

Interest in Biomedical Science

In high school, Leroy was not really interested in science and only took the basic science courses required for graduation. It was during his year at the community college that he "... got interested in science. Science was one of the things I really liked to do." When asked why he began to like science, he responded:

> It was because of the class. What really interested me was biology. It was like the study of life and I got really interested in life, with the sense of life or 'how,' the existence of life. That is where I got interested in it. Then I started thinking of going to school in other places.

After coming to NAU, Leroy enrolled in biomedical science courses due to his interest in biology and medicine. He later found out about the MSD program.

Cultural Beliefs about Medicine

Leroy's interest in medicine is partly due to problems he feels are related to the culture and customs of Navajo people. When he was growing up on the reservation, his mother would take him to the doctor or hospital when he was sick, but would also seek out the Medicine Man. It was believed both served a purpose and helped in the healing process. The problem, according to Leroy, was that the doctors on the reservation were typically not Navajo and therefore had difficulty with the language. They also had differing cultural beliefs and values about medicine. In Leroy's words:

> There is a real need, a very big need for American Indian doctors on the reservation. At the time I graduated high school, I went through several jobs. I was an EMT at one time too, and I've got the experience from there and I've seen that there was a need. The fact that there is a lot of miscommunication between doctors and patients [as] medical terms can't be translated into the language of the Navajos. There's like a big miscommunication right there. And it seems like the majority of the Navajo still seek traditional, holistic medicine.

Leroy also expressed cultural beliefs and taboos related to anatomy, physiology, and the study of medicine. For example, "as a Navajo person, you're not supposed to be around a dead body" or handle human tissue. Leroy justified his desire to disregard cultural taboos and study medicine by saying,

> There is a time for me personally [where] I look at it as you just have to accept things if you want to learn the things to expand your knowledge. So it is more of a personal decision for most people. It is kind of hard to get away from it but if you really want to expand your knowledge, you have to do some personal adjusting.

MSD Program Experiences

While at NAU, Leroy heard about the MSD program from his pre-med advisor.

She told him the MSD program would be a good opportunity for him to become involved in scientific research related to the health of Native Americans. Leroy talked to the MSD faculty mentor for the Pulmonary Function Study and was hired. The research project was of interest to Leroy for several reasons: (a) it involved conducting research with his people on the Navajo reservation, (b) the research was designed for the purpose of improving the health of Native Americans, (c) he thought it would benefit his understanding of the research process and his course work, and (d) he would be paid for his involvement.

Research topic. Leroy has been working on the Pulmonary Function Study with the same faculty mentor since the beginning of the MSD program a year ago. Another MSD student researcher from the Hopi reservation is also working on the same study. Together, they travel to the Navajo and Hopi reservations to meet with tribal leaders and elders to gain approval and support for their study. After gaining approval, they set up appointments and meet with individuals to collect data by conducting pulmonary function tests. The tests involve having subjects take a deep breath and blow into a mouthpiece connected to a computer device called a spirometer. From this activity, lung size measurements are recorded, as well as the volume and flow rates of the exhaled air.

After testing hundreds of subjects, a nomogram or predictive table is statistically generated and evaluated across age and gender for both Navajo and Hopi subjects. A physician can go to a table and see predicted values to compare with actual measured values of a patient. This information is useful in the detection of obstructive (emphysema, asthma) or restrictive (pneumonia, sarcoidosis) lung disease.

Although pulmonary research was unfamiliar to Leroy before his participation in the MSD program, he quickly learned about the topic and became fascinated with the work. He believes the research serves a purpose as a potential health benefit for his Navajo people.

Leroy believes MSD research topics should be selected based on student and faculty interest in the topic, as well as a mutual belief in the importance of the research for the field of science. He believes topics should be original ideas and encourage student exploration. Topic selection should not be limited by availability of lab equipment or facilities.

Faculty mentor. The faculty mentor for Leroy's research has been instrumental in teaching both content and research methods. He designed the study and supervised data collection, analysis, and presentation of results. Leroy feels the faculty mentor provided excellent training and continued to supervise the work through regular interaction and communication. When problems arose, the faculty mentor was willing and available to assist. "When I need something, he's there, all the time."

Leroy appreciated the trust and responsibility given to him by his faculty mentor, and felt they had a good working relationship.

> There are times when I get all the responsibility and I really enjoy that. I think it is better to have someone have more trust in you to do the study. If he came every time I go out, he would tend to follow along like he didn't have any trust. I feel good when I go alone to take all the responsibility.

Overall, Leroy credited his mentor for being supportive and encouraging, giving him both direction and freedom. He also viewed his mentor as being a knowledgeable

leader in the field of pulmonary research.

Work schedule. Overall, Leroy said the MSD program "provides you a job that is very flexible compared to a regular job." The professors are willing to work around your class schedule and give time off as needed, such as to study for an upcoming exam. The number of hours worked per week varies from 10 to 50 hours, depending on the data collection schedule.

One of the difficulties has been scheduling the research around coursework at NAU, especially considering the large blocks of time needed to drive to the various reservations. Traveling to the reservations is time-consuming but necessary. In some cases, the trip to a reservation means driving 6 or 8 hours.

Conference attendance and presentations. The MSD program supported Leroy's out-of-state travel to two conferences. His first experience was a meeting of the American Association of Physical Therapists in Dallas, Texas that he attended with his faculty mentor. The conference was a surprise to Leroy.

> I didn't think things like this existed or I didn't think there was [sic] conferences like this for professionals to all go and met and talk about what they are doing and meet with their colleagues. It kind of made me want to go into research ... [and] strengthened my focus.

The second experience was the national meeting of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) in Washington, DC. The SACNAS meeting was also attended by 12 other MSD students and two faculty members. Going to the conference with other MSD students gave him the opportunity to get to know other students and share their common interest in science research.

Leroy's only presentation, so far, was at the MSD 99 Science Symposium held on the campus of NAU. After the presentation, Leroy admitted to being extremely nervous. He was intimidated by the large number of professors in the audience and worried about the questions they might ask of him during the question-and-answer period. While he had prepared responses ahead of time for questions he expected, he was asked different questions. In spite of being nervous, Leroy believed the speaking experience was valuable.

> What they [the MSD staff] did today was one of the best things they did. I think if they could continue doing that, it would be really good because it was a really good experience. Eventually I have to present at a national conference with my faculty mentor, and I think this is a good opportunity for me to get used to talking, just learning by experience. Like right now, I'm thinking, I should have done this, I should have done that. And that's really good because now I know what I can set in place and do again.

Leroy did not know if presenting research results at a conference was an expectation for students in the MSD program. He did mention that he thought MSD students were expected to publish their research results. To help prepare, Leroy was trained by his mentor to review current literature.

Influence on career goals. When asked how the MSD program has affected his goal of becoming a medical doctor, Leroy gave the following explanation:

> When I started [the MSD program] I did have a goal of going to medical school .... It seems like the MSD program strengthened my goal .... It gave me more hope and showed me I could do basically anything. It showed me there is a possibility that I can accomplish what I really want in science .... It provides you with more opportunities towards your professional goal. I think the MSD program is right on focus with their basic mission. It has been a really good opportunity for me.

Leroy saw the MSD program as an effective strategy for attracting and retaining

minority students in scientific fields of study and preparing them for future careers. He attributed this success to the opportunity students had to work with a mentor as they participated in their own research project. These research opportunities were seen as boosting self-confidence in science, as well as sparking interest and enthusiasm in scientific areas they knew little about prior to involvement in the program.

Suggestions for Improvement

When asked about weaknesses in the MSD program, Leroy had "no comments." Each time he was asked, he paused and thought for awhile but could not come up with suggestions. "I think the MSD program is right on its focus where their basic mission is; they are following everything. It is a really good opportunity I recommend to my friends."

Description of Subject 2: Samantha

Samantha was a senior at NAU working on a bachelor of science degree in microbiology with a minor in Asian studies (Japanese). She had been in the MSD undergraduate research program for 1 year. Similar to a few other students in the program, Samantha also worked at a part-time job off campus. Her ultimate goal was to go to graduate school and then work in a microbiology or immunology lab such as the Centers for Disease Control and Prevention. In the MSD program, her research was in the area of evolutionary biology where she worked with fruit flies in the genetics laboratory.

Family Background

Samantha was born and raised in Flagstaff, Arizona and considers herself to be a

"full-blooded Navajo Indian." Her parents, born and raised on a Navajo reservation in northeastern Arizona, met in a Native American missionary school. They got married and later moved to Flagstaff where they had three children.

Samantha considered herself to be a full-blooded Navajo Indian because of her ethnicity, yet she admitted to being brought up in "a white Anglo society with very little exposure to Native American culture."

Education

Samantha attended public schools in Flagstaff from kindergarten through high school. She was "pretty good in high school science" although it was "the most difficult thing I have ever had to study in my entire life." Other subjects (such as English, math, and art) were "easier and more fun."

She felt she was better prepared for college because she experienced a "traditional American education" by attending public schools in an urban setting. In contrast, her Native American friends felt less prepared for college as a result of attending reservation schools.

> Preparation [for college] is a big thing. Lucky for me, I went to school here [in Flagstaff] so going to college was nothing. For me, it was extremely easy to start school here, but I've had friends who I met who have come off the reservation and try to come to school here and say it is just too difficult. They get 4.0s on the reservation and then they come here and they get like a 2.0 or 2.5 and they are barely cutting it.

Interest in Biomedical Science

Samantha's interest in biomedical science was attributed to several sources.

During a field trip to the laboratory of the Flagstaff Health Center, Samantha "fell in love" with research in the area of immunology and working with viruses. Samantha was further influenced in this area by the movie "Outbreak" and the book "The Hot Zone." Both media sources "really inspired" her and increased her desire to work in biomedical research.

Another source of inspiration was a biology professor she had gone to for help in understanding the class lecture. After helping Samantha, he asked about her future plans after college graduation.

> It was actually the first time any professor had asked me what I wanted to do and I was impressed by that. He actually encouraged me a little more which was inspiring because I didn't think I could do it. It was really good for me to hear.

Samantha's interest in research was influenced by her preference for working in a "hands-on" environment. She felt that learning by doing was the best way to understand a concept. An example she gave was that working in the laboratory clarified and strengthened her understanding of genetics and starting new generations, as well as her understanding of the research process. She believed that learning the research process could not come from a lecture or a textbook, but must be experienced personally.

Her dream was to do microbiological research for an organization similar to the Centers for Disease Control and Prevention, but in a foreign country. She wants to work in Japan because of her minor in Asian Studies and 5 years spent studying Japanese.

Cultural Issues

Samantha's parents were very supportive of her decision to attend college and

pursue a degree in science, regardless of Native American taboos expressed by her grandparents. According to Navajo culture, it is taboo to handle human tissue. Her grandparents also did not approve of Samantha going to the Indian Health Services for health care as they did not want her to take medications or see a doctor. They preferred she went to the Medicine Man instead of the doctor. Samantha believed their opinion was based on tribal traditions and pride. She did not think her grandparents value the help of experts from different races because then you "don't know where they are coming from or what their background is."

Samantha openly expressed her opinions about educational experiences available to Native Americans. She was frustrated by the isolation she felt at NAU. As she stated, "I feel like when I go to class, I'm the only Native American there. And it's kind of like you are singled out ... and maybe pushed off to the side a little bit." Yet, she felt there were advantages for students just because of their Native American culture. For example, scholarship funds for Native Americans were seen as making it possible for students to attend college, regardless of preparation or ability.

> There's scholarship money for every minority, no matter what color you are, no matter what your grade is, you can still get into college. It's kind of disappointing for me because I feel like I don't have the expectations of somebody who is not a minority. It's good for me, but I don't think it is fair.

However, some Native American students that were admitted to college were there for the wrong reasons, and not for getting a better education.

> I just feel like maybe the Navajo tribe is funding students that can't even make it in school, or are doing it just to get away from home. I guess maybe their emphasis is somewhere else instead of going to school and

> getting a better education. Or, it's just for the money. I've seen that happen a lot of times. You know, it's really disappointing to me to see. As far as [MSD program admission] emphasis goes, they don't ask a lot of questions. The only requirement is that you are Native American and they give you money.

MSD Program Experiences

Samantha first heard about the MSD program a year ago from a friend who was also in the program and encouraged her to apply. Samantha thought it sounded interesting and went to an MSD staff person to get more information.

Research topic. Samantha was told there were two research positions available, one in chemistry and one in biology. She was more interested in the chemistry position but it was filled by the time she was able to reach the faculty mentor. When asked why she wanted the chemistry position when her degree was in microbiology, she explained that she had always been stronger in chemistry. She was disappointed that she did not get an assignment in chemistry but said, "Unfortunately, that's kind of how it works."

Samantha applied for the position in biology and was hired. Her research topic is in the area of evolutionary biology where she works with fruit flies in the genetics laboratory. Using cross-fertilization techniques with fruit flies in test tubes, she maintains specific generations of fruit flies and also creates new generations. "Pretty much, my life here is just the same thing, working with fruit flies." According to her mentor, the goal of the research is to use quantitative genetics and molecular biology to locate genes that affect longevity.

In the beginning, Samantha was confused about the relevance of using fruit flies

to study genetics.

> I'm in microbiology and so at first I was kind of thinking "fruit flies," of all things to end up doing! It was just that you would think that genetics and fruit flies don't go together. But in the research and stuff that I have been doing, they actually have a lot in common.

Samantha thought research topics for MSD projects were selected based on faculty interest, faculty belief in the importance for the field of science, the realistic adaptation to undergraduate students, and the opportunity for student exploration. She did not think topic selection was based on student interest or belief in the importance of the research.

> I have to agree it was luck that I got the position .... I wasn't really interested in genetics to begin with and if I had another choice, I would go into something with microbiology. But then again, genetics and all this stuff does incorporate with one another.

Faculty mentor. Samantha worked with the same faculty mentor during her year on the MSD research project. They tried to have lab meetings once a week to coordinate activities. The faculty mentor visited the laboratory on a daily basis to oversee the work. Samantha felt that she could easily contact her mentor if problems came up where she felt she needed his help.

Samantha felt her research experience could have been enhanced if her faculty mentor took time to "actually go through and teach us what happens before and after because we are only getting the now and that doesn't really help us as far as getting the whole picture." She did comment that her relationship with her mentor was "working well," "communication is great," and he "is really open to questions." However, she did not think her mentor thoroughly planned their research project, or was one who encouraged and motivated students.

Work schedule. Working in the lab required 10 to 15 hours a week. The hours were flexible, yet difficult for Samantha to schedule around classes and her off-campus job. Daily experiments scheduled a few weeks ahead by the mentor were shared with two other students working in the same lab. Samantha's portion of the work typically required a 2- to 3-hour shift to complete. While most lab time could fit around her class schedule, Samantha occasionally had to go in on weekends to get the work done.

Conference attendance and presentations. When asked if she attended conferences related to her research, Samantha said "No, but I am supposed to, according to the MSD. Luckily through the program they set aside money so you can travel once a year. That's really nice but I haven't even started to look into that because I'm so busy." She was hoping to find a conference in Japan and was told by the MSD staff that $500 could be used to help with her expenses.

On a few occasions, Samantha reported attending lectures on the campus of NAU where research results from her experiment were being presented. In one case, Samantha and others from the lab were available to answer questions. When asked if she was going to present at the upcoming MSD Science Symposium held at NAU, Samantha said she knew nothing about it.

While she believed that MSD students were expected to attend conferences related to their research, she did not believe that MSD students were expected to present or publish their research results. While not seen as an expectation, she believed that presenting and publishing research would be a beneficial learning experience, and one that would help prepare MSD students for graduate school.

Influence on career goals. Samantha's MSD experience reinforced her desire to go into a research career.

> It [my goal] still hasn't changed. I'd love to do research. I chose this goal, my career, just because it was challenging and I like a new challenge. I think my goals are stronger now, more so since I started working here just because I've seen that you work with people, you still have human interaction, you still communicate, and team work is so important.

Suggestions for Improvement

Samantha wanted to see more information circulated from the MSD staff about the program. She mentioned having "friends that are minorities that don't know about this program and to their knowledge .... I'm getting a higher grade ... so that's why I got the position." This lack of communication about the program and the application process could have been solved by "posting up flyers" around campus and putting an advertisement in the school newspaper.

Further publicity could raise awareness about MSD research projects as "it would be nice to let everyone else know about this program and gain information about minorities doing research." Students, both in the MSD program and those interested in research, would benefit from learning about the experiences of student researchers.

Samantha suggested changing the method of assigning students to faculty mentors and research projects so that "we would actually get to chose what we wanted to do" and not "get shoved into a field that you really don't like."

To help prepare students for graduate school, Samantha suggested MSD staff provide information to students about schools that have graduate-level science programs

for minority students.

> This whole program is driven to make graduate students. When you are not being given information on what's ahead, it doesn't really help. It would be kind of nice to know more about other graduate programs.

Samantha suggested changing the method of communication between MSD staff and students. "They inform us by email, but I don't really read my email very much so I'm pretty much out in the middle of nowhere. They should try the phone."

Description of Subject 3: Jeremy

Jeremy just completed a bachelor of science degree in biology with a chemistry minor at NAU and was finishing up his MSD research prior to moving to another university to begin graduate school. He had been in the MSD undergraduate research program for 1 year. His ultimate goal was to get his doctoral degree in biology and then do research, preferably in cell biology or animal physiology. In the MSD program, his research focused on studying the liver through metabolism and thermogenesis studies of cold exposure and exercise training of opossums.

Family Background

Jeremy was born in San Francisco and lived in various places in California for 10 years. While he was young, his parents divorced and he later moved with his mother to Phoenix. His mother was born and raised in Phoenix and has Irish ancestors. His father was born in Los Angeles, raised in the Philippines, and later returned to the United States as a young adult. Because of his father's background, Jeremy reported being 44% Filipino

and 6% Native American (Pima Indian). The MSD staff may not have known this information about Jeremy's ethnic background. According to a recent annual report written by the MSD staff, Jeremy was classified as "a Native American undergraduate student" (Nishikawa, 1999).

Jeremy claimed that his family is not educated because they did not go to college. As he described, "They're not really career people, just job people. My other siblings, it's the same sort of thing, they are not going to college. So I'm sort of the smart one in the family."

Education

Jeremy attended elementary schools in both California and Arizona, and secondary school in Arizona. Jeremy described the schools he attended as "standard" American public schools in urban settings. His high school in downtown Phoenix offered a variety of advanced placement classes, so he took courses in chemistry, physics, advanced placement biology, and integrated mathematics. He discovered that he "liked science" and decided to continue his studies after high school graduation by moving to Flagstaff to attend NAU.

At NAU, Jeremy started studying biology with the goal of becoming a biologist. "I sort of danced around different areas of biology, got into some ecology, then switched over to the cellular stuff, and landed in physiology. This is where I want to stay." After 4 years at NAU, Jeremy recently received a bachelors degree in biology with an emphasis in cell molecular biology and physiology function morphology, and a minor in chemistry.

Jeremy was proud to be the first one in his family to attend college and graduate.

Interest in Biomedical Science

It was in high school that Jeremy first became interested in biomedical science.

> That's where I learned that science was an option for the future. I think wanting to be a scientist is a dream that you figure out when you are 2 years old ... and you realize that you can eventually make it a reality when you are at the end of high school or beginning of college.

In college, Jeremy's interest in science changed from a general interest in biology to a specific focus on animal physiology. "In terms of narrowing it down, I think that clicked in my animal physiology class. That's when I realized that physiology was a branch of biology that I wanted to get into." His interest in physiology became stronger as he was further influenced by his participation in the MSD project.

> I was interested in the general area of just certain animal physiology, metabolism, the liver, and mitochondria-type things. But then, once I started diving in [to the MSD research project] I just really got swept up in the whole project .... I think I could work on this stuff forever.

Cultural Issues

Being brought up in White Anglo society in urban America, Jeremy did not feel that he was faced with issues associated with or related to culture. He seemed quite surprised when asked about his ethnicity and cultural beliefs as he did not consider himself to be a minority student. However, he was aware that being Filipino and Native American gave him the opportunity to become a participant in the MSD program.

MSD Program Experiences

Jeremy first heard about the MSD program when his animal physiology professor invited him to apply for participation in the program. He believed the professor recruited him because he was a good student in the class and very interested in animal physiology.

Research topic. Jeremy described his MSD research topic as "examining the response of liver tissue to cold-adaptation and exercise in the Brazilian opossum using quantitative transmission electron microscopy." His particular responsibility for the research was "what's going on with the liver."

In the beginning of his research work, Jeremy was uncomfortable and felt unprepared as he did not understand the topic. "When I first came in, I felt a little overwhelmed. That was actually good because it forced me to go read a little bit about it instead of having all this handed to me."

The more he learned about the function of the liver, the more he began to feel like an expert.

> No one else is really the liver expert around here. My particular thing has been thought of as liver metabolism. No one in this lab, nor anyone in the [NAU] faculty is really an expert on that stuff. A lot of the basic biology of some aspects of the study we really have to look up. Whereas, if someone were around that was an expert, they could just tell us.

Faculty mentor. Jeremy worked with three faculty mentors during his MSD research experience. "The amazing thing is how different each one has been. There's pros and cons to each one of course." His first mentor took time to teach him "functional techniques" in the lab. Another mentor emphasized "scientific thinking skills" or "how to approach a problem and think like a scientist." Jeremy thought learning the scientific

process from his mentor was "the best skill that I ever acquired. It's just been more effective than any class I've ever had or anything. It's just been the most phenomenal thing." Another mentor was skilled in showing Jeremy the "big picture" of how all the "little pieces" of the research project fit together.

All three faculty mentors were seen as experts in their scientific field with "amazing brain power." They gave Jeremy both direction and freedom in his work as they knew "when to sort of guide me and when to just let me figure it out for myself."

Work schedule. Jeremy appreciated being able to schedule his own hours on his MSD research project.

> It's completely flexible. If you want to work 1 hour [a week] or you want to work 20 hours, you can. But that's sort of the beauty of it. If you have 20 minutes between class, you can come and do one little piece. Otherwise, you can work longer. Just however much that week demands and you can do it.

Jeremy expressed frustration about the manner in which other MSD students took advantage of flexible work scheduling.

> Some people are really regimented about it and must work exactly 4 hours a day to get exactly 20 hours. I sometimes have a problem with that because it ends up with people that don't have any more experiments to do that week and they say, "Okay, I'll just sit around and read a book for 5 hours and get paid $8.00 an hour." That seems dishonest.

Conference attendance and presentations. Early in Jeremy's MSD research, he and his faculty mentor presented a poster of their research at a local conference of the Phycological Society of America. (Phycology is the branch of botany concerned with the study of seaweeds and algae.) Their poster was titled "Observations of the cytoskeleton and flagellar apparatus in Gonyaulax polyedra." The meetings were hosted by NAU for

about 450 people. He thought the experience "was great."

The MSD program supported Jeremy's out-of-state travel to Washington, DC in April of 1999 for a conference of the Federation of American Societies for Experimental Biology. During the conference, Jeremy presented his MSD research with a poster titled "Chronic cold exposure induces hepatic hyperterophy in the marsupial monodelphis domestica."

When asked if MSD staff expects students to present and publish their research results, Jeremy said "I think that is sort of an important goal, just so that you feel that you are working towards something. But, I don't know if that's necessarily the goal of everyone here." He saw presentation and publications as methods of boosting self-confidence in one's abilities and helping to prepare students for graduate school or future work in scientific research. His first publication was "in the works now" with a "first draft manuscript that I hope to have ready to launch before I go."

One of Jeremy's mentors worked to prepare students for presenting and publishing research by holding weekly meetings, like a journal club.

> Every week we have to read a [scientific research] paper and discuss it. We all take turns. Everyone in the lab selects a paper, puts a copy in our mailbox, and we read it and then discuss it. Just learning to read a scientific paper takes so much practice. Today it was my turn, so we talked about my manuscript and I got some great feedback.

Influence on career goals. Since he was a young kid, Jeremy knew he wanted to be "a scientist." In high school, Jeremy knew he wanted to pursue a career in the biological field of science. To prepare for his goal, he decided to attend college. Once he started college, he realized there was more to biology than just becoming a biologist, and he

began to narrow his focus to "a little finer point."

As Jeremy developed an interest in animal physiology and began working on MSD research, he further refined his goal to "conducting research in cell biology or animal physiology."

To achieve his goal, Jeremy planned to attend graduate school, get a PhD in biology, and then go into research. "At first, I had no idea I was going to go to grad school. That didn't come until half way through [the MSD experience]." He thought he may end up working at a university. When asked how he felt about teaching in a college setting, he was undecided.

> I've thought about that and I don't think I could truthfully give an answer right now until I've taught and really gone through some of those motions first. I think I'd like teaching but I'm not positive that's what I want to do for the rest of my life.

Suggestions for Improvement

When asked about recommendations for improving the MSD program, Jeremy responded by listing what he saw as strengths or benefits.

> More often than being disappointed, I'm pleasantly surprised. [The MSD staff assistant], in terms of the red-tape, she's just on it. It's just phenomenal. And then stuff like support for travel and things like salary, it just blows me away that it is there. So, in terms of finding things that are really lacking, it's hard to say.

After thinking for awhile, he did provide a few suggestions.

Jeremy mentioned a lack of communication by MSD staff about activities related to the MSD program. Brochures and notices were posted outside the MSD office, but "if you never came up to the fourth floor" you would not know about upcoming activities.

Yet, Jeremy was unsure what else could be done to improve communication. The responsibility is "sort of on the students end trying to receive it ... so it's up to them."

A suggestion was made that MSD students be expected to write regular summaries of their research activities. Jeremy thought students should be made accountable for their work and should be required to document their progress in a report at the end of each semester.

Jeremy questioned the purpose of having organized social activities for MSD students and faculty mentors. MSD staff "go through an effort to put together socials to sort of link people in different ways, but I personally have never been to one of these socials. It's just not my style."

When asked for advice to share with someone new to the MSD program, Jeremy said:

> I think once you're in, it's more self-explanatory. You just dive into how to do the science stuff and how to do research and how to think critically about those sort of issues. And that it's sort of sink or swim in that sense. I guess I would tell them it was definitely a positive experience and it is extremely valuable. It's almost too much, almost unfair for people who aren't in the program. It's amazing.

Qualities and Characteristics of the MSD Program

This section includes findings from the perspective of other MSD student participants, and MSD faculty and staff about qualities and characteristics of the MSD program (research question 1). These findings came from the following MSD data sources: interviews; focus group discussions; informal discussions; questionnaire

responses; attendance at faculty meetings and a symposium; and various documents.

Application Process

An organized process does not exist for publicizing the MSD research program and recruiting minority student applicants. Students learned about the program from a variety of sources. Typically, MSD faculty identified minority students in their classes and recommended they apply for the program. An advisor in the Biomedical Office suggested the MSD program to several students. In a few cases, students heard about the program from friends already involved in the MSD program.

Once a student learned about the program, an application could be obtained from an MSD staff person. To apply for the program, students were required to give the following information: (a) background--ethnicity, languages spoken, address, phone, social security number; (b) college--class rank, major, minor, grade point average, expected date of graduation, courses taken, other schools attended, transcript; (c) high school--school attended, date graduated, courses taken; and (d) personal statements--future professional goals and objectives, and interest in MSD research participation. A copy of the MSD application is included in Appendix F.

No official deadlines existed for the application process. Students filled out an application and returned it to the MSD staff person. If a research position was available, the student was directed to interview with the faculty mentor. Although no deadlines were given for application, students expressed feeling a need to "hurry and apply before someone else got the position."

Minority Student Participation in MSD Research

The MSD research program was designed "to provide opportunities for minority students to become actively involved in ongoing biomedical research projects with selected NAU faculty" (Nishikawa, 1997). Although this study focuses on undergraduate research opportunities, graduate students were also invited to participate in MSD research. According to MSD documents, student participation in the program from April 1998 to January 1999 included "a total of 20 undergraduates (9 Hispanics and 11 Native Americans) and 15 graduate students (1 African American, 4 Hispanics, 1 Pacific Islander, and 9 Native Americans)" (Nishikawa, 1999).

During the 1999 summer semester, MSD documents indicated participation by eight undergraduate students (four Hispanics and four Native Americans) and 10 graduate students (one African American, four Hispanics, one Pacific Islander, and four Native Americans).

Matching Students with Faculty Mentors

No particular method was used to match students with faculty mentors. As students applied for the program, they were directed to interview with faculty mentors that had open research positions. If more than one student interviewed with a mentor, the faculty mentor offered the position to the candidate of his or her choice.

Students preferred having a choice of mentors and research topics, but admitted to accepting positions even though they may not have gotten their first choice. The majority of the students reported being happy with their faculty mentors and felt they had

developed positive working relationships. Most of the concerns were from students who wanted to work with a different faculty mentor because they were not interested in the research topic they were assigned.

Style of Mentoring or Supervision

All students interviewed in this study felt their mentors were knowledgeable leaders in their scientific field. Most reported being encouraged that their mentors tried to develop open, working relationships with them; met with them on a regular basis; gave them both direction and freedom; and spent the time necessary to train them to properly use lab equipment. Most students felt that their mentors motivated and encouraged them and taught them appropriate research methodology. All students reported that mentoring usually occurred with one faculty working directly with one student. Occasionally, a faculty mentor would work with a small group of students. A few students reported being trained by their mentor to review current literature.

Several students felt that their mentor did not thoroughly plan their research projects ahead of time. Some students did not think thorough planning was necessary while others expressed frustrations with the lack of planning.

Several faculty mentors expressed frustration about working with unprepared or inexperienced students:

> I enjoy working one-on-one with the students but must be very patient in teaching the research process as many of the students lack the skills and knowledge I would expect them to have.
>
> It's a challenge to train them in research techniques as so many students lack preparation. We need to assess all students on science skills at the

> entry level. One of the problems is that we are faced with the cultural issue of training Native Americans to perform against their culture.

Typical Workload and Scheduling

Most students worked 15 to 20 hours a week on MSD research. The majority of research was in a controlled laboratory setting doing a variety of experiments. Some students reported variety in the typical work conducted on a daily basis while a few reported the work was "extremely repetitive."

Scheduling of work hours was intentionally flexible to meet the needs of the student. When students could not complete work around class schedules, they arranged to work weekends. Students submitted their hours to MSD staff by email on a regular basis.

Students and faculty mentors did report some academic challenges that were faced by students due to MSD research workload. One student reported spending more time in the library to better understand the research project. Another graduate student reported being paid for 20 hours per week but working much more, without pay, to keep up with the research workload. One faculty mentor felt that MSD research participation caused students to perform poorly in their biomedical courses as they had less time to study and devote to coursework. He raised the question, "Is time spent on research hindering academic achievement?"

Financial Support

All students agreed that being paid for doing research was a major benefit of the MSD program. They felt fortunate to be paid while learning a skill they saw as beneficial

to their educational and career goals. Most students reported being able to quit working other jobs off campus. "I was able to quit my waitress job and focus on coursework."

Besides being paid for hours spent working on MSD research, students also reported receiving tuition waivers. Another financial benefit was travel money set aside for students to attend professional conferences.

Faculty mentors also received financial support for involvement in MSD research. "A stipend of $5000 for participating faculty mentors was contributed by NAU" (Nishikawa, 1999).

Support from MSD Staff

Students praised MSD staff personnel for managing necessary paperwork in an efficient and timely manner. Students felt they received immediate attention to their questions, concerns, or problems. As one student said, the MSD staff assistant "is doing a fantastic job."

Faculty mentors also praised MSD staff personnel for efficiency but had several recommendations for improvement:

> The MSD staff needs to work on trying to find the right combination of what it takes for minority students to excel. More research is needed to identify programs, approaches, and motivators. It may help raise faculty awareness to take them to the reservation to let them experience the culture.

> My biggest concern is that the faculty group is not a cohesive group. Structurally, it isn't set up right. The turnover of faculty in the program makes it even more difficult. It would help if the MSD staff talked to the departments to resolve this problem.

MSD Program Expectations for Students

MSD program expectations were communicated verbally to students on an individual basis by MSD staff or faculty mentors. Students reported receiving conflicting messages regarding expectations to: travel to professional conferences, present research results, attempt to publish research results, or prepare for graduate school. Most students felt they should attempt to accomplish all of the above, yet they differed in areas they felt were required by the MSD program. Almost all students felt they were encouraged to attend a professional conference, but only half felt they were expected to present or publish research results. More than half felt they were expected to prepare for graduate school.

Presentations and Publications
by MSD Students

According to MSD documents, student participation in the program from April 1998 to January 1999 included attendance at professional conferences by 22 students, presentations given at a conference by 15 students, and six student publications. Attendance at professional conferences was seen as a beneficial learning experience. As one Hispanic student explained:

> I didn't think minorities were that underrepresented in science until I went to the Heart Association meetings. Out of thousands of people, I saw a total of about four Hispanics and two Black people. Everybody else was mostly White male. There were a lot of women but they were mostly lab technicians. I was sort of looking around and saw most of the minorities around were pushing brooms. It was actually an eye-opener for me.

During the MSD 99 Science Symposium held at NAU in August 1999, 13 MSD

students had an opportunity to present research results. A listing of student presentations given at the symposium is included in Appendix E.

Suggestions for Improvement

Two interview participants suggested students be involved in research during the end of their freshman year in college. Faculty tended to disagree, saying students should wait until their junior or senior year when they have more experience and a better understanding of science.

Several students and faculty suggested publicizing the program to other NAU departments and the Flagstaff community. They also expressed a desire to publicize and formalize the application process. According to one student, the application process is "a well-kept secret."

Most students expressed a desire to find out about the research topic and experiences of other students and faculty in the MSD program. Suggestions included: monthly support groups, one for undergraduate students and one for graduate students; socials with MSD students and faculty; and opportunities for students to "shadow" their mentor for a day. While some students recommended holding regular meetings of MSD students, others were relieved about the lack of such meetings.

Several students suggested a switch in research topic or faculty mentor assignment after a year in the program. While this was seen as giving students the benefit of working with a variety of mentors, some students thought it would not be feasible given the time commitment required to learn the specific techniques used in each lab assignment.

Summary

In summary, MSD program qualities and characteristics were as follows:

1. The application process was informal and publicized by faculty and students.

2. Minority student participation varied by semester, but was mostly comprised of Native American and Hispanic students.

3. No particular method was in place for matching faculty mentors with students.

4. Most mentoring occurred one-on-one and was strengthened by regular supervision where students felt motivated and encouraged.

5. Most students worked 15 to 20 hours a week on MSD research and reported flexibility in scheduling work to fit their needs.

6. Students reported financial support as the number one benefit for participating in the MSD research program.

7. MSD staff were efficient, attentive, and handled paperwork and problems in a timely manner.

8. Students were unclear about MSD program expectations regarding travel to conferences, giving presentations, publishing research, and preparing for graduate school.

9. Opinions varied as to suggestions for improving the MSD research program.

Career Goals of MSD Students

This section includes findings from the perspective of MSD student participants, and MSD faculty and staff related to career goals of the Native American undergraduate research students (research question 3). These findings came from the following MSD

data sources: interviews, focus group and informal discussions, attendance at a symposium, and various documents.

Focus Group Data

According to self-report data from focus group participants, career goals were influenced by participation in the MSD program. Students were asked, "What were your career plans when you entered college? What are they now? How has your research experience helped you get closer to achieving your career goals?" Table 5 shows student ethnicity, academic rank, and career goals before and after MSD program participation.

Table 5

Focus Group Data on Self-Reported Career Goals of MSD Students

Ethnicity	Academic rank	Career goal before MSD participation	Career goal after MSD participation
Native American	Undergraduate student	Nursing	Crime lab research
Native American	Undergraduate student	Elementary school teacher	Biological researcher
Hispanic	Undergraduate student	Microbiologist	Epidemiological researcher
Hispanic	Graduate student	Journalist	Chemistry teacher
Hispanic	Graduate student	undecided	Biological researcher
Hispanic	Graduate student	English teacher	Ethnobotanist or microbiologist

According to these students, they came to college with a variety of ideas for the future, only one of which involved a major in a scientific field. For various reasons, they changed majors to biomedical science and applied for participation in the MSD program. Once in the program, they had the opportunity to learn the research process and were exposed to a variety of careers in scientific research. Five of the six students planned to pursue careers that included scientific research. Participation in the MSD research program greatly influenced their career choice. The other student hoped to teach science at a college level, and admitted that her experience in MSD research resulted in an interest in chemistry but a disinclination for research.

Students agreed MSD research had greatly increased their self-confidence in science. Many reported a previous fear of both science classes and the process of research. Increased self-confidence was mainly attributed to support given by their faculty mentors.

When asked about the influence of the MSD program on their career plans, one student gave the following response:

> I would not be in a master's program in biology if it weren't for the MSD program. I would have taken my bachelor's and done something in science, but I would not be in a master's program and considering a doctoral program without this [MSD] program.

Another student added that she was counting on the MSD program to support her career goal as she was "going into my graduate program in the fall" at NAU.

MSD Faculty and Staff Data

Faculty and staff attribute participation in the MSD program for attracting and

retaining minority students in biomedical fields of study. Rather than focusing on career goals, they use educational goals as benchmarks. The belief was that career goals may change over time, but educational preparation and training leading to the goal show that students are seriously preparing for future careers. Therefore, indicators used to measure MSD program success in preparing students for biomedical careers were the educational degrees obtained in the biomedical sciences, or those in process.

Table 6 includes data on degree obtained and degree being pursued by students in the MSD program. Degrees obtained were from NAU, while degrees being pursued include NAU and other institutions as noted. Excluded from the data were (a) three students already represented in the in-depth study, (b) six students included in focus group data, and (c) undergraduate students.

One faculty member expressed pride in having an MSD student as the first Native American student from NAU that was accepted to Harvard Medical School. Another faculty mentor describes the influence of the MSD program on career goals as an incremental change:

> The changes are occurring one student at a time. It is not a global difference, but an individual one. Some Native American students are going against cultural beliefs and family wishes to participate in this program.

Data from Other MSD Students

Informal conversations and interviews with other students in the MSD program revealed educational and career goals similar to those already presented from the in-depth study, focus group, and faculty and staff. No self-report data from students revealed a

Table 6

Faculty and Staff Data on MSD Student Preparation for Biomedical Careers

Ethnicity	Degree obtained	Degree being pursued/school
Hispanic	BS Biology	MD Univ. of Arizona Medical School
Hispanic	BS Biology	MD Univ. of Arizona Medical School
Hispanic	BS Biology	MD Cleveland Podiatry School
Native American	BS Biology	MD Harvard Medical School
Native American	BS Biology	MS in Biology NAU
Native American	BS Exercise Science	Physical Therapy or Medical School Undetermined
Native American	BS Biology	MS in Biology NAU
Native American	BS Biology	MS Exercise Science NAU
Native American	MS Chemistry	Physical Therapy Program NAU
Native American	MS Biology	PhD in Physiology Oregon State University
Pacific Islander	MS Biology	PhD in Pathology Mayo Clinic

disinterest in biomedical careers. If these feelings existed, they were not shared with the researcher. Also, no data revealed MSD students who had quit the program, were

planning to quit, or had dropped out of school. As students in the biomedical program at NAU, one would expect their career goals to include biomedical professions.

Summary

In summary, career goals of students participating in the MSD program have been influenced in the following ways:

1. MSD research participation gave students the opportunity to learn the research process and exposed them to a variety of careers in scientific research.

2. Through the support of faculty mentors, students gained increased self-confidence and interest in scientific research careers.

3. Faculty and staff attributed participation in the MSD program for attracting and retaining minority students in biomedical fields of study.

4. Self-report data from students attributed MSD research participation as greatly influencing career choices.

5. Faculty, staff, and students attributed MSD research participation as leading to graduate school opportunities that would not exist otherwise.

DISCUSSION

The present study examined the undergraduate biomedical component of the federally funded MSD program at NAU. An emphasis was placed on understanding the MSD program from the perspective of Native American student participants. The intention of this section is to review research findings, discuss implications for MSD program improvement, present limitations of the study, and suggest avenues for further research.

Review of Research Findings

The first research questions asked, "What are the qualities and characteristics of the MSD program from the perspective of the Native American undergraduate research students?" and "What implications do expressed qualities and characteristics of MSD have for program improvement?" To answer these questions, MSD students, faculty and staff were interviewed and observed in the research setting. An extensive description provided the background and perspectives of three MSD students: Leroy, Samantha, and Jeremy. The perspectives of other MSD students, faculty, and staff were presented and findings were summarized. The question about implications for program improvement is addressed in a later section.

The second research question asked, "How have career goals of the Native American undergraduate research students changed while participating in the MSD program?" To answer this question, MSD students, faculty, and staff were interviewed.

Detailed descriptions for Leroy, Samantha, and Jeremy were followed by findings from the perspective of other MSD student participants, faculty, and staff.

The third research question asked, "What influence does cultural background have on career goals of Native American students in the MSD undergraduate research program?" To answer this question, Leroy, Samantha, and Jeremy were asked multiple questions about their cultural and ethnic background and beliefs, as well as cultural background and beliefs of their parents and grandparents. They were asked to describe the history or development of their career goal(s). At each stage of change or development in the stated career goal, students were asked for factors that influenced their decision. Findings were presented individually for each student.

For the purpose of this discussion, ethnicity is defined as belonging to a particular race or people, based on common ancestry, culture, history, tradition, language, and physical characteristics (Banks, 1988). Cultural background refers to the influence of the society or community on a person's social and intellectual growth and development. Culture involves an integrated pattern of behaviors including thoughts, communications, behaviors, rituals, beliefs, traditions, and values that are all common to a particular group (Banks & Banks, 1995).

During this study, a question surfaced regarding the ethnicity of one participant. In selecting Native American undergraduate students for the in-depth study, Jeremy was chosen based on his willingness and the recommendation of MSD staff. However, the researcher discovered during an interview that Jeremy considered himself to be "6% Pima Indian." While various Indian tribes and organizations have opinions on requirements for

ethnic classification, the question remains unanswered as to how the MSD staff and funding agency determine Native American status.

Another issue related to ethnicity surfaced while interviewing Leroy, Samantha and Jeremy. Although the students were chosen for Native American ethnicity, it was discovered that differences exist between their cultural backgrounds. Leroy was born and raised on the Navajo reservation in a traditional American Indian culture. Samantha's parents were raised on the Navajo reservation, but she was born and raised in Flagstaff's "white Anglo society with very little Native American culture." Jeremy was raised in urban America to a mother that was mostly Irish and a father that was mostly Filipino. Therefore, by comparison: (a) Leroy's background was ethnically and culturally Native American; (b) Samantha was ethnically Native American, but culturally Anglo-American; and (c) Jeremy was an ethnic mix, though classified as Native American, and had an Anglo-American cultural background.

Differences between ethnic and cultural backgrounds of Leroy, Samantha, and Jeremy may help explain the experiences and perspectives they have about the MSD program. For example, the fact that Leroy even went to college was a major accomplishment, given his economic status and being raised in a family that did not value education. It seems that college attendance was more accessible and affordable for Samantha and Jeremy, given their cultural backgrounds. While background knowledge may be helpful in understanding experiences and perspectives, analysis becomes more difficult. Knowing that minority students differ on ethnicity and cultural background makes it more difficult to hypothesize the influence of the MSD program on Native

American participants. Further study is needed to investigate ethnicity and cultural backgrounds of minority students participating in similar research programs.

Implications for MSD Program Improvement

As an evaluator for the MSD program, the researcher had many opportunities to gain insight into various aspects of the program. During the 1-year period, nine trips were made to the NAU campus to plan the evaluation, attend meetings of faculty and students, talk to individuals and groups, observe activities and research, and gather documents. From these experiences, the researcher was better prepared to make recommendations for MSD program improvement.

General MSD Program Goals

According to the grant proposal submitted by NAU to the National Institute of Health, the MSD program was designed:

> To increase academic performance, retention, and graduation rates of under-represented minority students, especially Native Americans, who are or who could become interested in careers in biomedical sciences. As a result of this program, we hope to increase rates of acceptance into and completion of post-graduate degree programs in biomedical sciences at NAU as well as at other institutions across the nation. (Nishikawa, 1997)

Findings from this study confirm success in some of these areas. Minority students involved in the MSD program reported an increased awareness of biomedical careers and an increased self-confidence in their ability to conduct scientific research. Students attribute the MSD program with influencing their decision to attend graduate school and pursue careers in biomedical sciences. However, these success stories are on

an individual case basis and are not yet seen as being program-wide. While these overall program goals are important for understanding the philosophy of the MSD program, they were not the focus for this study. Evaluation of these overall program goals should continue through the life of the grant.

Specific Goals of the Research Component of the MSD Program

For this study, the research component of the MSD program was evaluated by comparing program goals to perspectives of faculty, staff, and students in the biomedical science departments at NAU. The specific goals of the research component of the MSD program, as listed in the grant application, were:

> To provide opportunities for minority students to become actively involved in ongoing biomedical research projects with selected NAU faculty. Students will be encouraged to give presentations on their research at national meetings of scientific societies and to publish the results of their research in peer-reviewed scientific journals, with faculty co-authors. (Nishikawa, 1997)

In response to these specific goals, findings from this study confirm that minority students, mostly Native Americans and Hispanics, were given the opportunity to engage in research with selected faculty. Students in the program would like more information about the program and felt a need to formalize the application process. Students also reported being unclear about MSD program expectations regarding presentation and publication of research results.

MSD Program Qualities and Characteristics

Findings from this study are restated below and followed by evaluative comments

and recommendations for program improvement:

1. Finding: The MSD application process was informal and publicized by faculty and students. According to a review of literature, effective programs provide sufficient time for the application process. The MSD program would benefit from formalizing the application process and communicating the process to faculty, staff, and students in the biomedical science departments at NAU. The process should include providing literature about the program, information about the application process, deadlines dates for submission, selection criteria, information about faculty mentors and interviews, and the method of communicating selection results.

2. Finding: Minority student participation varied by semester, but was mostly comprised of Native American and Hispanic students. The MSD program has been very successful in involving and retaining minority students. The program would benefit from continued progress in this area.

3. Finding: No particular method was in place for matching faculty mentors with students. When possible, faculty mentors and students should be matched on interest in the research topic and on personality, or the ability to work together. It should remain the responsibility of both the faculty mentor and the student applicant to determine compatibility during the interview process.

4. Finding: Most mentoring occurred one-on-one and was strengthened by regular supervision where students felt motivated and encouraged. Faculty mentors should continue to focus on providing supervision and motivation to individual students. Faculty mentors should be given time during professional development meetings to discuss and

compare experiences in working with research students.

5. Finding: Most students worked 15 to 20 hours a week on MSD research and reported flexibility in scheduling work to fit their needs. Faculty mentors need to continue supervising student workloads and assist students where problems arise in scheduling research around class schedules.

6. Finding: Students reported financial support as the number one benefit for participation in the MSD research program. No action needed.

7. Finding: MSD staff were efficient, attentive, and handled paperwork and problems in a timely manner. No action needed.

8. Finding: Students were unclear about MSD program expectations regarding travel to conferences, giving presentations, publishing research, and preparing for graduate school. MSD staff need to clarify expectations with students, specify whether these activities are required or recommended, and communicate such decisions with students. If required, program staff must state consequences for not meeting requirements. MSD staff should continue financial support of student attendance at professional conferences. Faculty mentors should continue preparing and assisting students in these activities.

Overall, the MSD program made a significant impact on minority students involved in this study. Based on self-reported data, student educational aspirations and career goals have been greatly influenced by participation in undergraduate research. While Native American students in this study reported cultural taboos against certain aspects of biomedical careers, they were able to justify and overcome cultural pressures.

Limitations of This Study

By accurately portraying aspects of the MSD program from the perspective of Leroy, Samantha, and Jeremy, this research was designed to provide understanding and insight from a student perspective. Interpretations and recommendations based on research findings were limited to qualitites and characteristics of the MSD program. No attempt was made to generalize results across other programs or to other students enrolled in the program who did not participate in this study. Additionally, no attempt was made to track students to verify that stated career goals were achieved.

Avenues for Further Research

Further research is needed to evaluate the effectiveness of the MSD program by tracking student participants over time to answer the following questions:

1. Did MSD students complete advanced degrees?
2. What jobs did they find after college?
3. Did their jobs include biomedical science research?
4. Did their career match their stated career goal? If not, why?

Other questions could be asked related to minority students not in the program, or MSD students that drop out of the program:

1. What were the experiences of minority students not in the program?
2. Did they obtain advanced degrees?
3. What were their career goals?

4. Did students drop out of the MSD program?

5. If so, why and what career path did they follow?

As previously mentioned, further study is needed to investigate ethnicity and cultural backgrounds of minority students participating in similar research programs

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APPENDICES

Appendix A

Focus Group Questions for

Undergraduate Researchers

1. What effect has involvement in undergraduate research had on your ...

    - coursework?
    - GPA?
    - attitude about research?
    - attitude about science?
    - self-confidence in science?
    - future career plans?

2. As far as your career plans are concerned ...

    - What were your career plans when you entered college?
    - What are your career plans now?
    - Has your research experience helped you get closer to achieving your career goals?
    - If so, how?

3. What opportunities have been provided for you by NAU to share your research with others?

    - Have you attended conferences related to your research?
    - Did you present your research?

4. What are the benefits of being involved in the program?

5. What are the challenges of being involved in the program?

6. What advice would you give to other students applying for this program?

7. What advice would you like to give to the NAU faculty in order to improve the program?

Appendix B

Interview Questions for MSD Faculty and Staff

Person Interviewed: NAU Role:
MSD Project Role:

1. What do you think is the **purpose** of the MSD program?

2. What **activities** are associated with the MSD program? Which have you been involved with?

3. To what extent do you see **Native American students** involved in all phases of the MSD program? Are other minority students involved?

4. From your perspective, what do you see as **major outcomes** of the program to date?

5. Have there been **successes** associated with the MSD program? What are contributing factors? What has inhibited success?

6. What **impact** is the MSD program having on **faculty**? Describe any changes in attitude and teaching attributed to the MSD program.

7. What **impact** is the MSD program having on **students**? **NAU** as a whole? How can the impact be extended?

8. Have you noticed any **changes in how the Native American community views** or responds to the **university** that are associated with the program?

9. What does the **MSD program staff need to be doing** (changes, additional activities, etc.) that it is not currently doing?

10. Are there **lessons** about implementing such a program that you think would be **helpful to others**? (Please describe)

11. **What else** should I know to better understand the program and experiences you have had because of your involvement?

Appendix C

Interview Questions for Three Subjects

1. How did you find out about the MSD program?
   Describe the application process.

2. How long have you been involved in the program?
   Describe your faculty mentor(s).
   Describe your research project.

3. Why were you interested in the program?
   What are the benefits for students? for faculty? for the field of science?
   Do you know other MSD students?

4. How were you assigned a faculty mentor?
   Did you already know him/her?
   How often do you meet with your faculty mentor?
   Are you given enough or too much supervision?

5. How were you assigned a research project?
   Were you interested in the research topic before you joined the MSD program?
   After working on the project, has your interest level changed? Describe.

6. What were your career goals before and after involvement in the MSD program?
   Has the MSD program influenced your career goal? Describe.
   Has your cultural background influenced your career goal? Describe.
   Has your family influenced your career goal? Describe.

7. What is your family, educational, and cultural background?
   What is your definition of Native American?
   Does culture influence your study of science?
   How does your family view your involvement in the MSD program?
   How does your family view your educational experience?

8. Have you had the opportunity to attend conferences, present your research or publish your research results?
   Are you aware of the upcoming MSD 99 Science Symposium?

9. What suggestions do you have for improving the MSD program?
   What changes would you like to see in the program?
   What advice to you have for interested or new students in the program?

Appendix D

MSD Research Questionnaire

Check one:

☐ I am a student researcher for the MSD program.
☐ I am a faculty mentor and have worked with MSD student researchers.
☐ I am on the NAU faculty but have **not** supervised MSD student researchers.
☐ Other:_____

Based on an analysis of the literature, effective undergraduate research programs have the following qualitites or characteristics. Please mark the box which gives the best response to the following statements as they relate to the MSD research program.

FACULTY MENTORS:	agree	disagree	don't know	doesn't apply
meet with students regularly to monitor progress				
motivate and encourage students				
teach research methodology				
train students to review current literature				
give students both direction and freedom				
are knowledgeable leaders in their scientific field				
train students to use lab equipment				
thoroughly plan their research project				
provide tours of their research lab/facility for students				
provide tours of other research labs/facilities for students				
try to develop an open, working relationship with students				
STUDENTS ARE EXPECTED TO:	agree	disagree	don't know	doesn't apply
progress at their own speed				

work hard; yet are free to make mistakes				
be creative				
present research results				
attempt to publish research results				
prepare for graduate school				
try to develop an open, working relationship with their faculty mentor				
RESEARCH TOPICS ARE SELECTED BASED ON:	agree	disagree	don't know	doesn't apply
student belief that the research topic is important for the field of science				
faculty mentor belief that the research topic is important for the field of science				
realistic adaptation to undergraduate students level of experience and understanding				
finding a topic that is an original idea				
being of interest to the student				
being of interest to the faculty mentor				
opportunity it presents for encouraging student exploration				
availability of funds and/or financial support for the research				
availability of lab equipment				
availability of lab facilities				

FINANCIAL SUPPORT PAYS FOR:	agree	disagree	don't know	doesn't apply
student participation				
faculty mentor participation				
the purchase of lab equipment/supplies				
STYLE OF MENTORING INCLUDES:	agree	disagree	don't know	doesn't apply
faculty mentors work one-on-one with students				
faculty mentors work with several students at a time				
students are matched with faculty mentors by interest in the research topic				
SCHEDULING IS BEST WHEN:	agree	disagree	don't know	doesn't apply
longer periods of lab time are allowed (such as more than 3 hours at a time)				
there is sufficient time for the student to apply for admittance to the program				
students begin experiencing research by their junior or senior year				
MSD FACULTY AND STAFF PERFORM THE FOLLOWING FUNCTIONS:	agree	disagree	don't know	doesn't apply
encourage minority students to apply				
plan social activities for the MSD students				
provide forums for MSD faculty and students to share ideas and research				
attempt to involve faculty mentors from various departments across campus				
raise community awareness of MSD activities				

BENEFITS TO MSD STUDENTS INCLUDE:	agree	disagree	don't know	doesn't apply
hands-on approach of learning by doing is an effective method for discovery learning				
understanding of science and research is unrivaled by any other aspect of curriculum				
research experiences help students develop close relationships with mentors				
students are given the opportunity to present and publish research results				
students develop skills in creative problem solving				
research experiences boost self-confidence in science				
students learn the value of hard work and perseverance				
BENEFITS TO MSD FACULTY MENTORS INCLUDE:	agree	disagree	don't know	doesn't apply
insight and enthusiasm is gained from working with students				
faculty tend to publish more than their colleagues				
faculty tend to receive more grant funding than their colleagues				
students provide faculty mentors with extra help for research				
departments tend to allow faculty mentors more time to try new ideas or experiments				
faculty mentors tend to change their teaching style to meet student needs				

THE MSD PROGRAM BENEFITS THE FIELD OF SCIENCE BY:	agree	disagree	don't know	doesn't apply
increasing the nation's supply of scientists				
attracting and retaining students in scientific fields of study				
increasing participation by minorities and women in scientific research				
demonstrating value in the meaningful application of science principles				
the intrinsic value of the research in contributing to the field of knowledge in science				

Appendix E

MSD 99 Science Symposium

Student Presentations

Biology

- Extreme Halophiles: Background Physiology, and Protein Antibiotics
- Stereological Analyses of the Ultrastructure of Tongue Protractor and Refractor Muscles in Anurans
- Connective Tissue and Its Role During Tongue Protraction in *Rana pipiens* and *Bufo woodhousii*
- Temporary Cyst Cycles in the Freshwater Dinoflagellates *Peridinium volzii* and *Peridinium inconspicuim*
- Temporary Cyst Cycles in the Freshwater Dinoflagellates Glenodinium
- Female-Biased Sex Differentiation in the Bullfrogs from a Fish Hatchery Suggest Environmental Endocrine Disruption
- Rattling Efficiency of the Western Diamondback Rattlesnake, *Crotalus atrox*, May Be Due to Storage of Elastic Recoil Energy

Exercise Science

- The Effect of Inorganic Phosphate on the Contractility, Fatigability, and Recovery of the *In Vitro* Rat Diaphragm
- Construction of Pulmonary Function Nomograms for the Navajo and Hopi Nations

Chemistry

- Electron Microscopy Studies of Mitochondrial Ultrastructural Changes Upon Exposure to Chromium III Complexes
- Synthesis of Chromium-Coordinating Peptides for Characterization of Chromium-DNA Protein Crosslinks
- Incorporation of Phytoremediation Strategies into the Introductory Chemistry Laboratory
- Particulate Matter (PM-2.5 and PM-10) in Flagstaff, Arizona

Appendix F

MSD Program Application

NORTHERN ARIZONA UNIVERSITY MSD Advisor_____

MINORITY STUDENT DEVELOPMENT PROGRAM

Application for Participation in the MSD Program

Date_____

Name_____ Social Security no.:_____

Background Info

Ethnicity: ☐ Native American tribe: _____ ☐ Hispanic ☐ Pacific Islander
☐ African American ☐ White/Caucasian ☐Other_____

Languages spoken: _____

Local phone: _____ Local address:_____

Permanent phone: _____ Permanent address: _____

College Info

Class standing: ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior
☐ Graduate expected date of graduation _____

Major: _____ Minor: _____ Cumulative GPA: _____

Faculty Advisor: _____ Department: _____

High School Info

High school attended: _____ Date graduated: _____

Community colleges attended (if any, include dates): _____

_____

High School science, math, or computer science courses taken: _____

_____

_____

College science, math, or computer science courses taken: _____

_____

_____

Personal Statements

Future professional goals and objectives: _____

_____

_____

_____

Please provide a statement of your reason(s) for applying to the program (continue on the back if necessary): _____

_____

_____

The completed application must be accompanied by a copy (unofficial is acceptable) of all college transcripts (if applicable) and should be returned to the MSD Office, BIO 423.