Research Foundations on Successful Participation of Underrepresented Minorities in Information Technology

Final Report from a Cyberconference

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1. Executive Summary

This report chronicles a Cyberconference, Research Foundations on Successful Participation of Underrepresented Minorities in Information Technology, including the issues raised, important research topics and its conclusions and recommendations to the community.

1.1. Introduction

Changes are sweeping our computer-intertwined real lives in many different directions and our society is being further fragmented, not only by levels of education, financial status, and ethnic background, but also by accessibility to and knowledge of what Herbert Simon called "the world of the artificial." Just as with many other education-related issues, but this time more pervasively, the world of interactions with computers has extended from programming to dialogs and navigation in virtual and simulated worlds of information that will further divide our children and adults into "haves and have-nots." The underrepresented minority population in the United States, while increasing in numbers, is decreasing in numbers of people entering the computer field at a time when the bounty of new opportunities seems to be rising without end in sight. Large segments of the population, on the basis of ethnicity and gender, are not participating in proportional numbers in supplying the information technology needs of the nation. Why? What can be done about it?

1.2. Description of the Conference

The stated purpose of the conference was to disclose the fundamental research issues underpinning the success factors for the participation of underrepresented minorities (OMB definition) in careers at all levels in Information Technology, and in particular, Computing Science and Engineering. The minority groups of concern for this work include African Americans, Hispanics, and Native Americans.

The conference was conducted on-line during the months of October and November 1999 (see http://www.cise.nsf.gov/itminorities.html). It was sponsored through Grant EIA-9910768 of the National Science Foundation (NSF), and utilized electronic media provided by NSF. (Concurrent with this conference NSF sponsored a second conference that sought research issues related to the under representation of women in Information Technology-for further information see http://www.cise.nsf.gov/women.html).

Phase I of the conference in October began by announcing the conference and its goals, and provided an open forum for discussion of the stated topic. The conference announcement suggested initial discussion within five categories: Outreach, Teaching, Research, Mentoring, and Other, noting that each minority group might have some issues different and some the same within each category. Phase II in November presented summaries and analyses from Phase I, and received further input from both previous and new participants. One hundred thirty-six people registered for one or both phases of the conference, of whom about forty provided a total of 204 substantive inputs.

The project principal and co-principal investigators, together with 17 other scientists/educators oversaw and moderated the two phases, and subsequently analyzed and interpreted the results of the two phases. In December 1999, this project leadership met via teleconference and later with NSF staff to further analyze the inputs from the Cyberconference.

1.3. Conference Outcomes

The body of the report identifies in considerable detail issues and recommendations derived from the participant input and organized under the topic categories shown above. Because many of the findings clearly overlap these categories, and some defy categorization, the following summaries are listed independently from the original five categories. This was not a surprising result, as the initial categories were only intended as a framework to stimulate discussion.

1.3.1. Issues

The following ten issues with sub-issues provided the framework for seeking significant research topics. Highlights include the needs of different individuals, different minority groups, and the need to match these with the new and projected opportunities and needs for IT. The need to determine and seek an appropriate balance between research and action was at least implicit and frequently explicit in the discussions.

1. **Aggregation vs. Separation**: Not only do major differences exist among the three identified minority groups, but also significant differences may occur within each group, particularly due to geographic and demographic variations. Clearly some common problems exist, but even where they do, solutions may differ from group to group, and within groups, by such variables as region, gender, and across the scientific sub-fields. How should programs best be structured and to what degree of specificity?
2. **Coordination and Previous Work**: Much previous and recent work, both on research and implementation has been done, but its systematic and timely archiving has not been done. Data and knowledge from the efforts of public and private agencies, scientific societies, etc. is not organized, and difficult to obtain. How can active organizations better coordinate their efforts and share their results? How can modern information systems contribute to this goal?
3. **Research vs. Assessment vs. Implementation**: Many past and existing programs have obtained results that have not been adequately evaluated. Resistance to assessment and evaluation is universal, and is certainly not limited to this topic. What balance of research and implementation programs is now needed? How best can future efforts build on previous work? What lessons have we learned about each of the ethnic groups?
4. **IT Needs for Human Resources**: The needs at all levels of knowledge are so great that revolutionary directed efforts to improve participation of minorities may be needed. Research universities are leaders. How can they and their faculties succeed with minority students, and impact the rest of education? How can educational quality be maintained and the future potential of the graduates not be short-changed in the rush to rapidly prepare for employment? How can IT education be optimized to effectively reach minorities at all levels?
5. **Mentoring**: Much evidence suggests that mentoring can be a major factor in helping minorities to succeed. Good and bad mentoring can occur in many environments, including all levels and types of educational institutions, in differing styles and media, and by peers as well as by more experienced persons. These and other variables may

affect different minority groups differently. How can mentoring be better understood, best applied, and made most effective?

6. **Minorities at Majority Institutions**: Most minority students matriculate at majority institutions. These institutions and their faculties have many resources to create IT access, but lack incentives to focus on minority needs. Opportunities include prototype distance learning activities, partnerships with minority institutions, and integration of research and education including minorities. What are the potentially best roles for majority institutions, and how can they be fulfilled?
7. **Career Counseling**: Secondary School career counselors may be key to minority success in college. Their importance as mentors may be without equal. Their training regarding IT careers and their perceptions regarding minorities and IT careers may frequently be wanting. Is a major program directed at understanding and improving many facets of U.S. secondary school career counseling to minorities needed?
8. **Training vs. Education**: This traditional education issue (and sub-issues) is particularly significant here, both regarding the needs and sensitivities of the minority communities, and the status of IT jobs and careers today. Job opportunities and training programs for IT technologists abound, but may be limited in their long-range potential. How can the benefits of short-term training and longer-term education be maximized to meet the needs of individuals and the workforce?
9. **Relation of IT to the Basic Sciences**: Many of the lessons learned in motivating and retaining minority students in areas of science, mathematics, engineering and technology (SMET disciplines) do not seem to transfer directly to IT. We suspect that the motivational factors that are used in the sciences and engineering are of a different nature than those which stimulate the budding information technologist. What are the motivational and retention factors most significant in attracting and retaining IT minority students?
10. **The Multi-disciplinary, Changing Nature of IT**: Communicating to students, teachers, counselors, parents, etc., the nature and complexity of IT and its contrast to the Basic Sciences (SMET) is not easy. The IT community needs to acquaint and attract non-practitioners to IT, for example conduct analogs to science fairs, and other public events. What techniques will help students and their mentors to understand the nature, utility, interest and excitement of IT?

1.3.2. Summary of Identified Research Topics

Each of the following topics contains within it a multitude of research possibilities. The report presents these as prime possibilities, but does not suggest that they are all-inclusive, that research projects should necessarily focus within any one of these listed, or even that this list should constitute the only priority target for the community. It is representative of what the community of contributors and moderators considered important research areas.

1. **Access**. Access to computers and networks are key issues. What factors most affect access for all groups, for each group and for individuals in different regions, far from and within cities? What ways would serve best to quantify and catalog these factors? What techniques would be most likely to succeed in solving problems related to access?

2. **Nature of IT**. IT needs a definition and vision that would provide a common thread among the many facets of IT. What elements within IT fit best with the needs and interests of minorities?

3. **Existing Reports and Databases**. Many previous studies and projects contain a wealth of information on IT and minorities. Synthesis, collation, archiving, interpretation, and analysis should be considered and carried out for current and future research and implementation. Should a national clearinghouse or IT minority workforce workbench be constructed? Perhaps create coordinated IT databases with proper search and taxonomy features?

4. **Training and Education**. Short-term training may lead to good but limited jobs. Research is needed on ways to make the connection between training and education as seamless as possible, optimally an integrated continuum. How can initial IT training provide a path to minorities developing further into more broadly educated computer scientists and engineers?

5. **Career Selection by Minorities.** Many factors must affect career selection by minorities beginning at very young ages and continuing. Research is needed to identify these factors as they relate to IT careers, and to apply that knowledge to improve both access and entry. How to improve aptitude certification and counseling, especially at the secondary school level needs significant study.

6. **Quality of Teaching IT.** Many projects have aimed at improving and assessing teaching of minorities at all levels. What can be found from these to improve, recognize and award quality teaching specifically in IT for minorities? What factors are important in improving both future teachers and the current teaching force in IT?

7. **Distance Education.** Distance education looms ahead as a major factor in teaching and learning. What are its implications for minority participation in IT? Are there special benefits or deficits in distance learning for minorities in general, for IT in general, for minorities in IT?

8. **Advanced Degrees.** Workforce shortages in IT at higher academic levels are perhaps as significant as at lower levels. Graduate schools and industry increasingly rely on foreign citizens. What are the long-term consequences? Research is needed on the social, economic, and educational factors that deter or slow down U. S. minority citizens from continuing to higher degrees and career success in IT.

9. **Mentoring.** Conventional wisdom declares the extreme importance of mentoring in helping young people, especially minorities to succeed. Codification, analysis, and synthesis of existing knowledge are needed. Research should determine the most and least effective mentoring techniques and conditions, and point to novel and more effective approaches.

10. **Self-Reliance.** All individuals must take responsibility for their own development and ultimate success and minorities are often on their own and without guidance in a fast moving IT technology. What factors are most important in enhancing self-reliance, self-development, and life-long learning for IT minorities? Can these qualities be taught? What materials would be most useful? What must every IT professional know, and how will an IT professional continuously manage to maintain currency?

11. **Assessment and Impact.** Both past and future work should contain appropriate metrics for evaluation and impact assessment. Although evaluations exist for many individual IT projects and programs, integration and synthesis with an emphasis on quantification are necessary to inform future IT work. Research and development related to better standardized and quantified assessment instruments toward providing a consistent body of knowledge are essential. How can long-term IT educational efforts, based on strong social and political will, be planned with flexibility to adapt appropriately to rapid changes and be regularly evaluated to assure sustained quality of results?

1.3.3. Conclusions and Recommendations

In summary, the conference participants found that both needs and opportunities are great for research on the factors relating to underrepresentation of the minority groups in an array of Information Technology careers. The research should take the form of both synthesis and integration of existing data and information, and the generation of new knowledge in areas not yet addressed.

The problems extend throughout the educational spectrum, from kindergarten through graduate school. These problems that exist generally are exacerbated in IT due to its newness, its rapid expansion and growth, and its multidisciplinary, pervasive character. Additionally, research questions in some cases will be unique to a single minority group, even subgroups, but may pervade all groups or be different in different regions even for groups of the same ethnicity. This determination constitutes a major research question in itself.

Finally, the conference demonstrated a normal dichotomy of beliefs and concerns for the proper balance between research and action. Clearly, research is necessary, and a program with long-range goals should be established. At the same time, this should not replace nor does it displace the need for action programs, such as mentoring and accessibility, which can and are having proven impacts, but which will benefit greatly from systematic study.

1.4. If you would like to know more about the Cyberconference …

Persons interested in the conference in greater depth are invited to peruse the conference Web Site that contains much more detail on the activities and findings, and the complete statements provided by the participants. It can be accessed at:

http://www.cise.nsf.gov/itminorities.html.

1.5. Opportunity to Research the Foundations of Minority Participation in IT

You will find in the Appendix V of this report a copy of the "Dear Colleague" letter that has been released by Dr. Ruzena Bajcsy, Assistant Director of NSF's CISE Directorate and the NSF suggested possible topics in Appendix VI. The spirit of the initiative announced in the call for proposals is part of the broader picture of researching how to increase the workforce in Information Technology (and part of the Information Technology Research effort of NSF/CISE) and how to help this through increased participation of minorities and women in IT. It is very much in the same spirit of our Cyberconference.

The NSF Website for this announcement is http://www.nsf.gov/cgi-bin/getpub?nsf0077.

We are hopeful that many will submit proposals to this program, as appropriate, and that you may help us publicize this opportunity. Notice please that the deadline for proposals is June 22, 2000. Some examples of research topics appropriate for proposals for this solicitation are given at the end of the letter.

2. Introduction

2.1. Information Technology Research and Change and Ethnicity

We recognize only too well the speed of change of technology and its effects on the pervasiveness and increased bandwidth of information media. Since this technological change has increasingly significant effects on the educational and economic development of the peoples of this country it will also become a vital instrument of democratic and social change if it is accessible to all and if its content is optimized for proper educational and for positive motivational objectives across ethnicities and social class. Similarly, the participation of women in Information Technology was well below their representation in the population and a virtual conference on that subject was run parallel to this one. We found that a large number of issues were different.

In this Cyberconference we have endeavored to seek what research is necessary to identify what are the barriers that cause ethnic underrepresentation in Information Technology and how to best remove them. We seek causes of the problem and investigate how to optimize the solutions to it through change.

We have found that this is a many dimensional problem that has been investigated independently by many from a wide variety of perspectives. We also find that little effort has been dedicated to the integration of those various perspectives and that little attention has been given to a systematic public archive that accurately reflects the extent and variety of those varied attempts to understand or solve the problem by a gamut of government, professional, and private entities.

At a time when our teachers in K-12 are faced with students acting like adults earlier than ever, we find that there is a wide gap between students and teachers at that level and their college and university peers. The problems in starting to attract high school students to information technology are quite different from those at the college and university level, where the task is somewhat easier. Unfortunately we had a disappointingly low participation of high school teachers in our Cyberconference, but that fact was an indicator of itself of the problem. At the high school level there are local budget and space constraints, lack of understanding of information technology by teachers and administrators, and insufficient knowledge of what would lead to a professional career in IT versus some intuition that some rapidly acquired knowledge in IT could land a good paying job immediately. At the college level it seems that the perspectives presented to the student are one of more choices of a mathematically oriented curriculum, a computer science and computer engineering curriculum with a strong physics and calculus requirement, or a business information management

> *"I have been disappointed that there has not been more talk of the K-12 arena. I think we need to get minority children interested and show relevancy at the grade school level. On reservations the children don't even know a career in computer science is even an option for them.... I'm sure this is true in other minority communities... I think we need to have a major push to highlight the career opportunities for minority youngsters. Make it attractive and make it relevant to their own cultures and communities."* —Karen Buller

perspective. There are many other title variants on these choices but they are fundamentally partitioned as described. It is interesting to realize that many more students transfer out of information technology into other disciplines rather than into information technology from other disciplines, except for the few cases where the student had already a background in mathematics (calculus) and science (mostly physics, also others). This does not apply to business-oriented information technology where the mathematics and science requirements are significantly lower. There is a significant gap between these two orientations that has not been fully faced by science oriented government agencies.

We also found that not only is there significant variance in the social, economic and cultural outlooks for a given ethnicity, but there is also significant geographical variation for groups of the same ethnicity. Our statistics often sweep over these and other differences, in a natural effort to cluster trends and provide measures. Often those statistics do not represent the same ethnic groups although they have the same or similar labels at different points in time, but it should be recognized that collecting statistics is an inherently difficult task. Clearly, if the collectors of statistics knew what we were looking for, they could do a better job of their process.

Finally, coping with a variety of issues and the magnitude of the problem is a daunting task. The proposal presented to the National Science Foundation, which is discussed in another segment of this final report, was mostly oriented to the even more difficult task of isolating the research topics that would lead to a better understanding of the causes of underrepresentation. Continuously, during the Cyberconference the tendency of the participants was to gravitate toward the offering of potential solutions rather than to the analysis of the root causes of the problem. In the opinion of many of us, it was a true reflection of the perceived paucity in obtaining documentable or obvious results. One of the participants did a clever back-of-the-envelope computation given the projected needs of the IT industry, the productivity of academic programs, and the representation of minorities in those programs, and the result led to a dismal picture of the almost impossibility of solving the problem of underrepresentation. It seems very difficult even to satisfy the projected needs with non-minority workers. But at the same time, it points to the state of crisis that both problems are approaching and their importance in the national interest.

In attempting to attract a broad range of inputs, the topics were divided in five areas. The initial intent, broadened by the participants themselves, was reflected in our description of the five clusters of potential research topics:

- **Topic Cluster 1 – Outreach**. The outreach section works with the following types of issues:
    1. How can institutions and industry work with elementary and secondary school systems to provide access to computer technology?
    2. How can students be motivated and properly prepared to move into the study of computer fields in college?
    3. How can computer careers be viewed by minority students as being important to the economic and social well-being of their communities?
- **Topic Cluster 2 – Teaching from K to PhD**. The teaching section works with the following types of issues:
    1. How does the cultural and social environment affect success in school?

2. How much information about computer fields is available in public schools, especially those with significant minority enrollments?
3. How does exposure to computers in the early school years affect interest in computing as a career?
4. How does instructor competence in computer technology affect the interest of students to pursue computer careers?
5. How much can students learn on their own versus what must be taught in the classroom?

- **Topic Cluster 3 – Research**. The research section works with the following types of issues:

    1. What is the relationship between grad programs at minority institutions and the support given to them by majority institutions?
        a. How can the cooperation between the two types of institutions be improved?
        b. How can majority institutions assist in ensuring that minority students with advanced degrees get the guidance necessary to insure their success?
        c. How can majority institutions remove the sense of isolation felt by many minority students at these institutions?
    2. How does diversity integration (in organization and salary structure) in industry differ than that of institutions, and how does this affect career paths?
    3. How do institutions recruit more minority faculty?

- **Topic Cluster 4 - Mentoring**. The mentoring section works with the following types of issues:

    1. How do institutions benefit from such programs?
        a. How can institutions recognize the need for such programs?
        b. How are faculty encouraged to participate, and how are they taught to be caring, committed, and competent mentors?
        c. How do institutions reward good efforts?
    2. What are the positives and negatives of attempting to implement such programs?
        a. What makes a good mentor, and how can they be identified?
        b. How do institutions encourage faculty to participate?
        c. How can institutions avoid overburdening faculty who take on this new role?
    3. How can other important groups (family, industry, other students) be included in these programs?

- **Topic Cluster 5 - Other Topics**. This section works with all postings that do not fit in any of the previous categories.

Furthermore, there were two Phases in this Cyberconference, which unfortunately were not perceived as fully differentiated by the participants. In the first Phase we hope to state the salient aspects of the problem, and in the second Phase, the intended concentration was on the areas of research that would disclose how to tackle the problems. The outline of the five phases given above was intended as motivation for the first phase, and the summaries of the first Phase were intended as motivation for the second Phase. This did not work as well as hoped, but many

carefully crafted responses were pointers to deep research issues. The responses were as follows:

- The **"Outreach"** topic had 48 postings in the first Phase and 26 in the second for a total of 36% of all postings. The fact that it was the first section may have had something to do in attracting the most attention among participants but maybe it was the topic.
- The **"Teaching from Kindergarten to PhD"** topic had 36 postings in Phase I and a disappointing 8 in Phase II for 22% of all postings.
- The topic on **"Research"** had 18 postings in the first part and only 5 in the second. It constituted the smallest of all topical cluster postings with 11%. It should be noted, for clarity, that this was not about research on minorities but on research on research success by minorities and similar topics.
- **"Mentoring"** was a very broad topic about which it was said that much is known and written about. There were 31 postings in the first Phase and 11 in the second. It was the third most popular topic in postings, with a broad range of views in 21% of all postings.
- The **"Other"** topic, intended as a catch-all for a variety of issues, attracted 10 postings in Phase I and 11 postings in Phase II, and it was the only segment whose popularity increased in the second Phase, for a total 10% of all postings.

It should be noticed that Phase II was approximately one week shorter than Phase I (four weeks) and that there was a diminished participation after the initial few weeks. However, new people posting appeared throughout the Cyberconference. Also, since registration was required for the conference we counted the number of registrants, which vastly exceeded the number of people who posted. Some of this may have had to do with some difficulties in the mechanics of posting, but clearly there were more people interested in reading the writings of others than in producing their own.

In the following pages and in the appendices we describe several aspects of the Cyberconfence that deal with its implementation and relative success. The purpose of those sections is to help a future designer of a similar project. The reader interested in reaching the substantive results of the conference inputs and conclusions should concentrate on the Recommendations section and on Appendices III and IV, although valuable aspects that provide context in greater detail are distributed throughout the text of the report.

2.2. Background on the Problem

The computer science community and the U.S. government and its agencies have been increasingly concerned about the lack of proportional participation of large segments of the American population in engineering and the sciences in general, and in information technologies in particular, specially after the recent unprecedented growth of that scientific and industrial segment. The term "digital divide" has been coined by the National Telecommunications and Information Administration and has been used in a series of well-publicized reports ([NTIA 99], [NTIA 98], [NTIA 95]). Additionally, the National Science Foundation's Division of Science Research Studies of its SBE Directorate, under Congressional mandate, has produced a sequence of nine biennial reports on the status of "Women, Minorities, and Persons with Disabilities in Science and Engineering" that have been oriented toward the educational and research involvement of these segments of the US population. The most recent of those reports [SRS 98]

and others, clearly indicates that, for some ethnic groups their participation in the computing sciences proportional to their presence in the national population is well below average. Also, the National Urban League, the Benton Foundation, segments of private industry, and professional organizations such as the IEEE Computer Society, the Association for Computing Machinery and, in particular the Computer Research Association [CRA 99], along with the US Department of Commerce [DOC] have been concerned about the dual problems of scarcity of information technology (IT) workers and the underrepresentation of minority segments in the IT field. Most recently, on December 9, 1999, as part of a conference on the "Digital Divide" [DDS 99] President Clinton outlined plans for closing the gap [CLINT 99] and charged the Secretary of Commerce with planning [DALE 99].

In the face of the earlier flurry of high-level reports and the impending funding of the "Information Technology Research" initiative, we proposed an open conference via the World Wide Web in trying to find the opinion of the community on specific needed research that would facilitate increasing the number of underrepresented minorities in the IT field. Co-coordinators for this conference were Oscar N. Garcia of Wright State University, in Dayton, OH and Roscoe Giles, of Boston University, Boston, MA. A diverse group of "moderators" also participated in the shaping of the virtual conference and served as a resource for a wide variety of questions. The names and addresses of the moderators are shown in Appendix I. The proposal for this "Cyberconference" as we called it, is shown in Appendix II. A rather extensive report on issues of human resources in IT and on national and regional needs has been issued by the Office of Technology Policy of the Department of Commerce of the U.S. [OTP 99].

It is most important to point out that the national need for IT workers is significant, so not only does it become important for social development to open the field to underrepresented minorities but they are also a source of untapped human resources. The nation needs minorities in IT and minorities need to participate in the mainstream of this technological development if they are not to lag further in the three dimensions of educational background, social environment, and economic status.

The degree of underrepresentation of minorities (and of women) in the IT academic field in Computer Science is clearly reported by NSF's SRS [SRS 98]. We display the indices (ratio of percentiles of minorities graduating over percentile representation in the overall population) for BS, MS, and PhD degrees for five ethnic groups (White, non-hispanic; Asian; Black, non-hispanic; Hispanic; and American Indians or Alaskan Natives) in the first three of these graphs in Appendix III from 1989 to 1995. It is clear that the only overrepresented minority is the Asian group (overrepresentation is a number over 100%). If we zoom in the plots leaving out the Asian group, the last three charts indicate the degree of underrepresentation of the Black, Hispanic, and American Indian populations over that time period. More recent data after 1995 is just now becoming available but not in time for inclusion in this report.

2.3. Proposal for a Cyberconference on Research in Minorities in IT

A proposal was written and funded by the National Science Foundation to try to determine what research could inform on the best remedial actions for underrepresentation of these ethnic groups. The proposal is included as part of this report because it conveys our initial thoughts and the premises on which it was based (see Appendix II). Fundamentally, to reduce costs, the study was carried out via electronic means to which we tried to attract a varied

constituency of underrepresented minorities. The proposal contains the rationale and details on the conduct of the Cyberconference.

2.4. The Execution of the Cyberconference

The two virtual conferences, having as objective the determination of needed research to increase the participation of women and of minorities, were carried out with the assistance of the information systems staff of NSF. While the contents and formats were designed by the proposers, the hardware and software used were those of NSF. The format used was based on the Domino Lotus Notes software. It was probably a bit more complex in some aspects, but it did provide some degree of security that was necessary. Only in one instance did a message have to be deleted for being considered totally improper. The process of first registering and then posting a message, which had to be followed in that order for first time registrants, may have deterred some from posting who were not comfortable with the use of this type of system. At times the system indicated that a posting had not occurred while it indeed had taken place; the user naturally posted a second time, which later had to be corrected. A better software setup should be used in future conferences of this nature. Continuous support by the same staff would also have facilitated the conduct of the Cyberconference.

There were a total of 204 postings and a total of 136 registrants for the minorities Cyberconference reported here. However, of the total number of registrants only about 30% posted which gives credence to the difficulty of posting or perhaps the interest in the topic but not the desire to communicate their ideas on the subjects. We have speculated that the issue of more interest in "seeing rather than being seen" on the Internet is one of potential research value. It must be said that the great majority of the postings were substantive with different but not very divergent points of view. The first phase had the greatest participation and went on for one week longer than the second. The postings and the summaries written have been kept in the web site http://www.cise.nsf.gov/itminorities.html and are available for reading at the time of this writing. There was a great variance with the frequency with which each posting participant posted a message. The average was 3.7 postings per posting participant, but the variety of topics brought up and discussed was quite significant given the 40 different persons posting. We could isolate at least 52 relevant issues from the postings.

In what follows we list the issues presented for each of the five topics during Phase I, from October 7 when it opened to November 4, 1999:

Topic 1: Outreach

1.1 Objectives of Outreach
1.2 Access first
1.3 Access is not equal for all ethnic groups
1.4 Common and uncommon problems/ priorities of each ethnic group
1.5 Community Computer Centers
1.6 The Need for a Relevant Vision
1.7 Creating a Vision of IT is Difficult
1.8 The Relevant Vision must be Simple
1.9 More on Community Computer Centers

Topic Cluster 2: Teaching K-Ph.D.

2.1 Back to Basic needs: SMET Courses and Native Americans
2.2 Technology and Connectivity; Parental Involvement
2.3 Well Applied, Relevant, CBTs can help Minorities
2.4 On Recognition of Teaching and on Teaching Minorities
2.5 Comparative Cost of SMET Curricula
2.6 "The Pipeline" - The Graduate School Branch
2.7 Distance Education - Internet Courses for Advance Placement

Topic Cluster 3: Research

3.1 U.S. citizens and Minorities in Graduate School
3.2 Is it rewarding to go to Graduate School in IT?
3.3 Affirmative Development
3.4 The Pipeline Model and Its Implications for Minorities with Undergraduate Degrees
3.5 Who will lead from within our communities?

Topic Cluster 4: Mentoring

4.1 Who and How Many? How do we scale up?
4.2 Isolation of Minority Students
4.3 Can we teach/learn how to be a mentee or mentor? - A Mentoring Course
4.4 Motivational Mentoring/Career Guidance?
4.5 Apprenticeship and Mentoring
4.6 Mentoring Minorities to Graduate School through REUs
4.7 The Pyramid of Mentoring
4.8 Research on Mentoring in Academia
4.9 Mentoring as a Topic of Research
4.10 Study Mentoring in a Social Context
4.11 Can Mentoring be Successful in Any Kind of Institution?

Topic Cluster 5: Other Topics

5.1 Different Issues for Different Minority Groups
5.2 Public Education and IT Proficiency Demonstration
5.3 A Women and Minority Self-Development Program
5.4 Vocational Test could Supplement HS Counseling
5.5 Technology, Race, and Income

and the <u>issues per topic presented during Phase II</u> from November 4 to November 24, 1999, with continued numbering:

Topic Cluster 1. - Outreach

1.10 Databases and reports
1.11 Reports and Issues Related to Native Americans
1.12 Technology, Race, and Income
1.13 Balance Between Education and Training
1.14 High School Computer Competition (HSCC)
1.15 Career Selection Process Must be Understood

Topic Cluster 2. - Teaching K to PhD

2.8 Selection of IT Careers by Capable Minority Candidates
2.9 Relevancy and Education

Topic Cluster 3. - Research

3.6 References and priorities

Topic Cluster 4. - Mentoring

4.12 Methods of Mentoring
4.13 Financial Goals and Realities

Topic Cluster 5. - Other

5.6 Inheriting ethnicity is not the same for all
5.7 The Strategy of the AIHEC
5.8 Career Counseling and Surveys
5.9 Vision and Definition of IT: What is an Information Technologist?

Other details in the conduct of the Cyberconference, such as the "netiquette" and other conduct guidelines, may be found in Appendix IV for future reference.

During the second phase of the conference we charged one of the moderators to visit community centers, high schools, and mostly Historically Black Colleges to survey perceptions and advertise our Cyberconference. A brief summary of his report is included in Appendix VII. His findings correlate with our concerns about available information and advice on IT careers available at the High School level.

3. Summary of the Issues Resulting from the Cyberconference Postings

All the issues listed and summarized below originated with some postings, usually within a discussion thread, but at times we combined several discussion threads that seemed coherent. The editing of the inputs received for the whole period of the conference (10/7/99 to 11/24/99) was kept to a minimum, short of providing raw inputs. The input summaries are organized with the corresponding topic.

3.1. Summary of Issues for Topic 1: Outreach

3.1.1. Objectives of Outreach

Four clear objectives are: 1) increase the number of home computers, 2) provide opportunities for students to see technology in use, 3) increase the comfort level of teachers with technology, and 4) allow infrastructure funding for technical support of computers in school use so that teachers can do their work, and are not burdened by the maintenance task. Expanding these objectives with more detail would include:

1. Improving the "Information Infrastructure" within target communities: schools, churches, and community centers could be primary starting points for any such program, including the equipment and expertise, with "ownership and responsibility" turned over to them once they make the commitment.
2. Minority IT professionals required at all levels. They are needed as mentors at target institutions within communities, as they are the best qualified to understand the complex needs within their respective communities.
3. Apprenticeship needs to follow mentoring (see Apprenticeship and Mentoring). It is necessary for students to see IT in action, and what better way than if they are a part of it. Some kind of tie-in to small businesses could be made. Small businesses lag behind the global net of corporations in IT. If a small business could get an IT apprentice, his mentor, and equipment to boot, for a minimal fee, it would prove to be a win-win situation for the business and also give something back to the greater community.
4. Near state-of-the-art or state-of-the-art equipment needs to be subsidized. The cost of information technology and maintaining its currency is one of the problems, or at least a factor in the low numbers of minorities moving toward IT careers. If there were limited resources and limited knowledge of IT, no one would be quick to spend money on something like a computer. With some kind of help, we would see an increase of computers in the home. They are needed for any global access program to succeed.
5. Last but not least, any form of outreach has to address fundamental perceptions and basic issues on the 3R's. When one looks at movies and TV, where real and imagined technology is shown, the imagination of the viewers tells them it is difficult, and they form some sort of stereotyped "geek" image of an IT professional. Contributing members to several kinds of outreach programs - the CyberEd Initiative and privately sponsored initiatives, for example, report that CTCnet groups who have the hardware and the space are in need of content. There are ways to create, share and show technology to

the communities that are in need of it. NASA, for example, has some great films which, unfortunately, are not well advertised. There are people like B. K. Fulton of the Urban League who will be seen because of the videos of PBS, but again, were there educators involved in those? Do the writers of the PBS tapes know about minority teaching situations? They could be major contributors to SMET outreach efforts.

3.1.2. Access first

There are vast regions that do not have network access. Does it make sense to have state or federal legislation to require telecommunication companies to guarantee in their service agreements access to network infrastructure for remote and isolated areas (such as in the southwest)? A national policy on connectivity may be roughly initiated by looking at existing connectivity maps of Internet coverage such as

- www.internettrafficreport.com or
- www.statmarket.com or
- www.cyberatlas.internet.com on sale by Matrix Information and Directory Services, Inc. as explained in their web site.

Local communities also must do their part to make themselves attractive and incentivize telecommunication corporations to provide access. Up-to-date statistics and demographic data about Natives Americans and their access to the WWW are in a report recently released by The Benton Foundation, titled "Native Networking: Telecommunications and Information Technology in Indian Country", which analyzes the critical telecommunications and information technology policy issues facing tribes at http://www.benton.org/Library/Native/ which references a Princeton Report published in 1995 http://www.wws.princeton.edu:80/~ota/ns20/year_f.html and the Department of Commerce completed a presidentially mandated study http://204.193.246.62/public.nsf/docs/EF11D9FADA118E25852567A700643EDC. Additionally, NMSU is hosting the project site at http://alpha.nmsu.edu/~tech/EDA/index.html.

There is quite a bit of information available, but the question is: "Is there anyone listening at the other end, willing and able to do something about access for all?"

3.1.3. Access is not equal for all ethnic groups

The United States Internet Council provides Internet participation rates for minorities. The full document, entitled "State of the Internet: USIC's Report on Use & Threats in 1999" can be retrieved from http://www.usic.org/usic_state_of_net99.htm. Quoting that document: "... But Forrester Research recently found that Internet access for black Americans is today at 23%, and that it will reach 40% by the year 2000. Access for Hispanics is today at 36%, and it will reach 43% by 2000. Americans of Asian heritage are most likely to be Internet users. The Forrester study found 64% of Asian Americans are on the Internet today, and projects that by 2000, 68% will be. So, while there are differences, there are also opportunities to appeal to underrepresented groups via cyberspace. In some ways, this restricts the usefulness of minority news groups: those who need them the most cannot get to them. It should be noted that geographically access is restricted by different factors, not just telecommunications. In parts of the Indian country, one of the key concerns is the stability of the power grid itself, especially as that grid relates to connectivity issues. At Bay Mills Community College's Nishnaabek

Kinoomaadewin Virtual College, for instance, one of the most important issues has to do with how often power fails at the college. This happens on a regular basis. One often takes for granted the stability of the service of the utilities, but in Indian country, huge chunks of territory don't even have telephone service. The question is how can we build a comprehensive access backbone that serves these out of the way communities as effectively as urban communities? Community infrastructure issues are also important. For the Navajo tribe of CO, AZ, NM, and UT, in addition to the sheer size of the territory, one of the problems in CBT is the disparity in the facilities available for connecting to the Internet. This includes different, incompatible telecommunication technologies as well as lack of local ISPs to connect the inhabitants of the reservation, outlying rural areas, and the schools. The ISPs usually involve long distance charges, therefore putting the service beyond the financial reach of participants.

3.1.4. Common and uncommon problems/priorities

What are the similarities and differences in the blocks that underrepresented minorities find in the road to IT education, and how do we determine priorities? The history of underrepresented groups shapes their view of education. One common thread could be that education is the most certain road to economic and social upward mobility for the great majority of people. We can conceive of different models to be researched and validated:

- "Priming the Pump Model" To what extent do minority Ph.D.s play a leadership (or "priming") role in creating more general IT-literacy? Do success stories get reflected back into communities of origin? Do successes become invisible because the target populations aren't aware of the IT culture? To what extent is within group mentoring a success factor in graduate education?
- the "Demographics Model" To what extent are younger members of target populations increasingly IT-literate, following patterns of generational differences often found, for example, in immigrant populations?
- the "Let Down from the Start" To what extent are members of target populations excluded from IT education because their basic education in, for instance, mathematics leaves them unprepared? Is this problem particularly bad for IT, or IT simply representative of other areas of learning that are pretty much equally affected by problems in early education? The overarching question is how are these models similar or different for each ethnicity.

Questions raised are if some funding were available, how would one prioritize and argue for the manner in which one would pay attention to the needs? In particular:

- How would we balance and investigate what are the common problems and which are different for each of the underrepresented minority groups? One thing is to acknowledge that both cases exist, another how to identify them.
- What methodology should we use to find out what are the most significant national causes that preclude underrepresented minorities to participate in education and thereafter in the IT workforce? Should we do it by region, and if so, how do we determine the regions?
- How do we measure the relative importance of making all underrepresented minorities IT-literate and able versus encouraging and funding their graduate education? In other

words, how does one make a case for the importance of solving the problem in an acceptable, rational, and scientific manner?

In general we can consider, at least, how minority problems are alike or different along the following dimensions:

1. educational background and preparation
2. environmental/economic/educational conditions (local unemployment, regional median Income, availability of suitable educational facilities)
3. family/peer-accepted value of education vs. other activities
4. social/family/peer/mentor support structure for educational attainment

These measures are likely to be different for different underrepresented minority groups and even different for minorities of the same group in different regions (for example, Hispanics in Florida vs. Hispanics in Texas). While there are likely common threads to the problem that we are trying to solve (bringing proper representation to IT) for all underrepresented minority groups, solutions may need to take into account at least those four dimensions mentioned above which may not be the same for all groups.

Minority Companies and Government: A number of minority companies (for example, those reportedly interacting with the black community such as BET, Essence, Ebony, Jet, Johnson Products, African Pride, Carter Savings Bank, Bill Cosby, HARPO Productions, Qwest, Bad Boy Entertainment, Def Jam, the 3 MJ's (Jackson, Jordan & Johnson), etc.) could possibly play a greater role. In the context of government agencies that promote R&D and education and human resource development (v. g. NSF, DOE, NASA, etc.) a collaborative *matching* program between those private entities mentioned above and the government agency might be a multiplying and coalescing factor, particularly if the private company itself became involved in helping. Maybe in addition to just donating funds, they could also become involved in "Technology and Training Educational Centers." The idea of legislation making telecommunications companies create 'community computer centers' in disadvantaged areas has also been mentioned. It is equally important that successful minorities who understand the community be placed in leadership and other 'role model' positions within those 'community computer centers' so that our young people may have a better sense of the possibilities for their future.

3.1.5. Community Computer Centers

These centers can take advantage of the population and infrastructure that is already available and so essential to connectivity. They would:

- Need multiple partners: government, industry, and community involvement
- Use the strategic advantages of urban centers

Communities in the urban center traditionally have extensive infrastructures. Power, phone, switching offices, public transportation, and highway access are common attributes found in these communities. They in essence are capital the community has to bargain with. Additionally, the available work force in terms of bodies is substantial. There is a strong work ethic alive in these communities. They could be coupled with a local economic development plan around a computer and education center that capitalizes on these advantages. Government

allocates the seed money where the computer center is used as a job-training site during the day. The Internet service provider, or similar business, that just moved into the area, because of the infrastructure, sees the community computer center as a way to develop an employee stream and decides to fund the center. There are many ways this can play out but government, industry, and the community need to be involved. The question becomes, "How can these partnerships develop, or be encouraged, for the benefit of the minority IT workforce development?"

One possible way to increase "outreach" to both urban and rural areas that are lacking access to technology would be to greatly increase the federal/state/local tax benefits for businesses and organizations engaging in such an effort, beyond the tax write-off for money or equipment donations. Such could include:

- commercial real-estate owners that provide low-cost space and/or all necessary build-out; this may be good for some of the smaller shopping centers that are having trouble keeping tenants due to the growth of larger malls.
- equipment manufacturers/distributors that provide new or refurbished hardware/software/ service,
- software manufacturers that provide special unlimited licenses for use with these non-profit centers,
- ISP's that provide web development, server hosting space, network engineering, or connectivity services,
- Telephone companies that provide local and long-distance service,
- New or used furniture manufacturers or distributors that contribute desks, chairs, etc.
- Business and administrative services (accounting, office management, etc.)

Cities and states could receive federal monies for having these centers; the amount should be directly proportional to the size of the city and number of areas with a concentration of people with below-average household incomes. By doing it that way, the proponents or opponents of Affirmative Action could not cry foul. Nonprofit companies could bid for the contract to run such a Technology Center. This would be to insure that no one company or entity gets too comfortable with running the center (whoever has the contract would have to stay on top of things in order to win the contract again the next time it is up for bid). Each instructor, educator, tutor, or curriculum developer could also be an independent contractor; thus they wouldn't be subject to the same trials and tribulations most public school teachers are subjected to due to the whims of their local school boards. These ideas, while all theoretical, might have some educational potential. Remember SimCity? It has had an impact on many young people who wanted to understand the complexity of social problems in growing communities. Perhaps we could have a similar realistic simulation game with the concept of Community Technology Centers. At least we could simulate how it would operate on a long-term and self-sustaining educational basis.

3.1.6. The Need for a Relevant Vision

How can a relevant vision of a field be shared, in different manners and contexts, for different ethnic groups/circumstances? From a previous message we have the following suggestions:

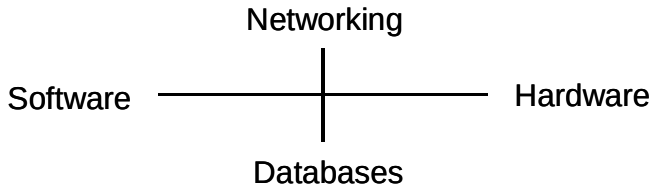
1. Use technologies/science of interest to the student
2. Make sure you ask them what they might "take home" from the experience, as ably explained above
3. Present the experience by a role model or someone to whom they relate, and
4. Help the students clarify their own "vision" by open discussion

3.1.7. Creating a Vision of IT is Difficult

The difficulty in creating a vision of the IT profession is the fact that it cuts across pretty much all other disciplines. While engineers can describe the "essence" of engineering we have not done the same for IT yet. How can we best describe the essence of IT? People have a high-level mental image of a computer scientist, but CS is only a portion of IT (the core, definitely). Perhaps the best way is to look at the computer as a tool, a platform, and not a goal within itself.

3.1.8. The Relevant Vision must be Simple

The vision must be articulated with examples and with simplicity. There are a number of things that even most potential students understand. Much of it is not in abstract IT but in "application's software," the WWW, an appreciation of knowledge and information explosion on the WWW, e-commerce, the digital convergence, etc. One very simple graphical map is:



with applications falling in-between.

3.1.9. More on Community Computer Centers

It seems that the idea of community computer center is being used right now. Officials of the City of Chicago report a goal of 1000 community "web centers" to be open by 2000. They intend to involve business from which cash or hardware would be solicited. NSF has been more proactive by committing $6M to EDUCAUSE to identify the networking needs of Black, Hispanics and American Indian institutions and provide a roadmap to their development of networking. EOT/PACI will receive $1M of that award. See: http://chronicle.com/free/99/10/99102901t.htm.

The new centers grant is for four years, and has two components. One is to help improve Internet connectivity, campus networks and networking support at tribal colleges, historically Black and predominantly Black colleges and universities, and Hispanic-serving institutions. The other is to assist interested minority-serving colleges and universities in developing and using advanced applications over networks. The award is good opportunity for each community to improve its networking capability on a system-wide basis by cataloging the networking problems at each participating institution; determining the desired solutions; locating funding sources and suppliers of the needed equipment, software and expertise; and then overseeing implementation of the solutions. We anticipate that one of the key features will be developing cooperative

remote technical support for campus networks, as a way to overcome the problem of hiring and retaining the technical folks needed to design and run the networks. The award potentially can help bridge the digital divide by providing the infrastructure over which the academic and research goals of the institutions can be attained. For more information contact dstaudt@educause.edu.

3.1.10. Databases and reports

It seems that a number of Federal Agencies, including NSF, report expenditures of at least $500,000 per year in one or more statistical activities as reported in http://www.fedstats.gov/noframe.html. Additionally the Census Bureau in http://www.census.gov is another excellence source of a wide range of on-line statistical data.

Of particular interest to the participants of this Cyberconference is the most recently released report (1998), the ninth of the Congressionally mandated series of the NSF Division of Science Resources Studies on "Women, Minorities and Persons with Disabilities" which is presented in a web-enhanced format and in other formats in

http://www.nsf.gov/sbe/srs/nsf99338/frames.htm.

Data about NAEP (National Assessment of Educational Progress) achievement levels is incorporated in the study.

The Computer Research Association published "The Supply of Information Technology Workers in the United States." See http://www.cra.org/reports/wits/cra.wits.html.

The National Telecommunications and Information Administration (NTIA) has produced three in-depth reports on race, technology and income. They are:

1. In July 1995, "Falling Through the Net" (http://www.ntia.doc.gov/ntiahome/fallingthru.html) nationally defined virtual class lines of the technological have and have-nots in rural and urban America.
2. In July 1998, "Falling Through the Net II" unveiled the digital divide (http://www.ntia.doc.gov/ntiahome/net2/falling.html).
3. In July 1999, the report "Falling Through the Net: Defining the Digital Divide," (http://www.ntia.doc.gov/ntiahome/digitaldivide). Added more data and color to Americans who were actually technologically falling behind. Obviously, after battling other issues of pay equity, housing discrimination, etc. families had run out of resources to provide technology in the home.

Similar issues appear in predominantly white institutions (PWI) where mentors are at times not very computer literate, and graduate students are not able or motivated to own personal computers.

Two important aspects to keep in mind related to our objectives with regard to IT success are: 1) the level of granularity used when considering minorities in reports, and 2) similar minority groups in different geographical locations do not have the same barriers. As examples, consider the Asian ethnic group which includes Chinese, Filipinos, Koreans, Japanese, Southeast Asians, or South Asians, which are groups representing different cultures but having similarities and differences. Likewise, the Hispanics in Texas and California face different barriers to education than those in Florida. The scenario for Native American is quite similar.

3.1.11. Reports and Issues Related to Native Americans

Summaries of the issues pertaining to Native Americans in 3 reports (July '99: Falling Through the Net III - NTIA; July '99: Assessing Technology Infrastructure Needs of Native American Communities - Commerce Department; and April '99: Native Networking: Telecommunications and Information Technology in Indian Country - Benton Foundation) are given by Evans Craig as Information Technology Among Native Communities in http://www.ahpcc.unm.edu/Alliance/Tribal/ITREPORT/sld001.htm. Other reports may be found in the Native American Distance Education Community Website at http://www.ahpcc.unm.edu/Alliance/Community/. These reports basically came up with the same information that the Natives have known for years, it just put it in official documents so that the federal agencies would fund the activities or recommendations suggested in these reports. Examples of the barriers identified in 1999 are:

1. A generally weak economic base that prevents Native communities from investing in infrastructure and upgrading the worker
2. Lack of skills to support a modern technology infrastructure
3. Geographic remoteness that raises the cost of providing technology
4. Distrust on the part of some Native Americans of specific new technologies
5. Lack of private investment on tribal lands
6. Poor information regarding the availability of federal assistance
7. Weaknesses in specific government policies intended to help Native communities improve their technology infrastructure

Examples of major barriers identified by a Native telecommunications conference in 1993 are:

1. The majority of American Indians do not have equal opportunities to be part of the nation's emerging "Information Highway" infrastructure.
2. There is currently no means of protecting the rights of Native American intellectual property owners who distribute their work through existing telecommunications systems.
3. Lack of telecommunications opportunities affect both access to information and education opportunity for Indian children, youths, and adults.
4. American Indian-owned telecommunications systems that are emerging are developing in a parallel rather than collaborative way.
5. Existing American Indian telecommunications service providers are committed to the development of a coordinated Native American Telecommunications System, but lack the resources and the collaboration necessary to assure quality development.

These are the major barriers identified, but there were 67 issues identified that needed resolve. There were also 35 different options identified that would address these issues.

If one looks in the previous reports for the Natives and in the reports sent out this year, one finds almost the same issues. However, one of the participants noted in Phase 1 that while all of us had assumed that infrastructure was "the" problem, we needed to look at other issues also.

Infrastructure, especially telecommunications infrastructure, is indeed a problem for Native Americans. The "digital divide" in Native Country runs right through the reservations, i.e., the main telecommunications artery for the southwest runs parallel with the Rio Grande River. The telecommunications artery similar to the "Silicon Valley" is generally referred to as the "Rio Grande Corridor." Along the Rio Grande River are the Pueblo's reservations. The RGC runs through these reservations and there is no access to the lines, even though the lines run right through their reservations. Lack of infrastructure means that there is no possibility to take advantage of distance learning and correspondingly, that there is no employment in the reservations for IT professionals or that employment is compensated at a very low rate.

Perhaps a recent NSF award to EDUCAUSE may provide for Community Centers in the Native American pueblos. Clearly, the dual issues of accessibility for more of the Native American population and the increase the human capital of Native Americans in IT are closely related.

3.1.12. Technology, Race, and Income

On July 6 of 1998 a panel titled "Technology, Race, and Income" met in Washington, D.C., with CSPAN coverage, to discuss problems related to low income earning urban populations, and their knowledge and access to technology. In particular, the high predisposition to use computers at home generated by acquaintance with computers at school and at work was cited. As in other panels of this nature, the panelists were more likely to present the problems and their solutions than to propose a scientific study of the problem. In the meeting it was stated again that there was a significant gap in underrepresented minority use of technology at work and at school, which indicated that this lack of access to IT would be transferred to the home also, thereby reducing automatically the future equalization of economic and educational opportunities for children of those minorities. The distinguished panel included Charles Kamasaki of the National Council of La Raza, Hillary Shelton of the NAACP, Hugh Price, President and CEO of the National Urban League - who had a most interesting support for a "technology opportunity tax credit," a refundable credit for the use of technology -, Roger Lyons, President and CEO of the Baltimore Urban League, Dong Suh, Spokesman for the Asian Pacific American Partnership - who apparently is very active in California - and David Honig, Special Counsel for the Rainbow/PUSH Coalition. The conclusion of a videotape review of the meeting was that there was more than just a problem with Internet access but also that the overall information access was a victim of the digital divide.

Availability of a truly personal computer at home or at a dormitory for minorities is anecdotally different than for non-minorities. However, the really important issue is to have some availability. Numbers of computers available are just as important as the quality of the use to which the computers are put. Use of computers just to be connected to the Internet, answering e-mails, but not learning about new software or through a distance education program is only partially important. There is also the question of whether the student has to (or wants to) work at home because of his/her family. Depending on budget and skills, maintaining and upgrading a personal computer can be a problem.

3.1.13. Balance Between Education and Training

The delicate balance between motivating potential IT workers and enabling them with a broad vision of the field, also relevant to their long term career path, shows in the close

association and support that industry (in particular Microsoft) provides to the Black Data Processing Associates (see the good works of BDPA with industry in http://www.bdpa.org and in organizing their "Computer Olympics" mentioned there also). The issue comes from the strong attraction of the immediacy of a job (as a Visual Basic programmer or some "software engineering certification" for example) versus the value of an education that goes beyond employment alone, but enables employment. There is no "right or wrong" in this issue since it seems more like a balance of how much to use of each approach. Potential IT workers must be made aware of the possibilities of professional careers in the field. Industry, because of its personnel needs and its natural ambitions to succeed in the marketplace puts training emphases on specific software application products. Industry would like to lead academic institutions to train their students on what they think is current and hot and they want to sell or use. On the other hand, academic programs (which take a four- or five-year time frame) like to emphasize what is fundamental and basic to operate in a social, economic and cultural environment for a longer term than the life of the most recent software application version release. It must be admitted that the complexity of some of those products is such that specific training is indispensable for their use. Should the industrial view of immediacy win over the longer-term cultural and foundational academic view, we would be subjected to the roller coaster of changing products and applications. On the other hand, the fast-moving business world cannot be ignored. The best balance may be to provide potential IT workers with immediate motivation but give them a well-crafted vision of the breadth and width of the IT field, if we can master such a broad vision. The great challenge is to do so within the short attention span that our fast paced audience provides us. And then later, incorporate industrial products as examples of specific cases when the basic principles are being taught (say a specific database product when teaching the subject). This is balancing a general education with specific training. The danger for an IT worker is that, once caught in the race to maintain job skills up-to-date, there will be no time for an education that would lead to higher level employment and thus they shortchange their careers. This problem is exacerbated for minorities, anxious to come into the mainstream of employment and for industry, wanting to attract them and have them learn their products first. The old saying that "to those who only have a hammer, the whole world looks like a nail" is more confusing in IT where there are thousands of hammers. Balancing these conflicting trends is a major challenge of IT.

> *"The student figures why sit in a class and learn the basis of computers without getting employable skills…"* —Tammy McBeath

> *"Let's face it no one is in school because they love the environment. They are looking for employable skills in market at the best salary possible…"* —Thomas Taylor

A BDPA Chapter, for example, establishes a training program that is part of the S.I.T.E.S program (Student Information Technology Education Scholarship). Under this training program there are three major tracks:

- The first is training in Visual Basic. This has two objectives: the first is to provide students some skills in the IT world that will allow them to get an entry level internship, the second to allow those interested to compete at the National BDPA High School Competition.

- The second track is to prepare those who show the interest and will stick with it, for Microsoft Certification.
- The third track is to educate students members on e-commerce and work with them in the development of a business plan that will allow them to launch their own e-commerce business. They also plan to work with the National Foundation for Teaching Entrepreneurship.

To meet these goals a Chapter, such as the one in Boston, purchases several computers and servers. They team up with other organizations such as MassPEP (Massachusetts Pre-Engineering Program), which is a pre-engineering program that focuses on Math and Science for minority high school students. Currently they are recruiting students for the first track training but different chapters have different activities and some are ahead of others in their plans.

3.1.14. High School Computer Competition (HSCC)

The National Black Data Processing Associates (NBDPA) carries out "Computer Olympics" at their annual meetings. The most recent one was in Atlanta and 120 HS students participated. Much could be learned from the HSCCs:

- How it has evolved/grown over the years
- Communities and high schools that participate
- Future prospects
- Statistics on the number of participants that have gone into IT college degrees

Some details exist in http://www.bdpa.org/conference/HSCC/hs-competition.htm. The students competing (no more than 5 students of 9th through 12th grades per chapter) are sponsored by BDPA Chapters, which also sponsor local community computer training camps for area youth during winter and spring months, and select the students to represent them at the national competition.

> *"A possible outreach program would involve organizing a Computer Olympics, specifically targeted to under-represented minority students and minority institutions…"* —Ricardo Gutierrez-Osuna

3.1.15. Career Selection Process Must be Understood

How do people in underrepresented minority groups select careers? Any, even minimal, researched insight into this question would be valuable. Possibly a cost-effective action the field could take would be to just provide curriculum materials that would show students what IT is like by providing example problems for them to explore and solve. (Would those curriculum materials be representative of field work?) This might establish a vision of what IT

> *Is there research available on how people, especially young people in various target groups, select their careers?* —James Coggins

> *"Those students who had positive experiences in pre-college years and were exposed to a subject that grabbed their interest--stayed on course."* —John Hurley

academic experience would be like. (It is doubtful that the verbal definition approach would be of much value.) We have anecdotal evidence that those students who had positive experiences in pre-college years and were exposed to a subject that grabbed their interest--stayed on course and that for them the monetary incentive of the career was secondary. As far as information technology also has engineering aspects, we should notice http://www4.nationalacademies.org/nae/NAE.NSF/00051c2a412ea508852565ed000b7b10/64aa1bbef6883c37852566f7006b7855?OpenDocument which is Bill Wulf's address to the National Academy of Engineering in 1998. He makes the points that we put the worst face forward (i.e. the nerd /fool image) and don't talk about or engage students in creative problem solving. He also states that diversity is an essential element needed for creativity of both the individual and the community.

Clearly, the question of the right image, the right vision recurs. Also recurring are the themes of counseling in HS and the lack of understanding by the counselors of how to advise students. It seems that the path by which students get into IT is less than direct, but even that seems to work because of the pervasiveness of the field and its wide applications. It seems that a key to advancing in IT is not so much the exact first career in which the person starts but whether it is somewhat close to the SMET disciplines.

US Black Engineer and Information Technology magazine publisher Tyrone D. Taborn as well as publisher of US Hispanic Engineer and IT magazines has created an annual event to help bridge the digital divide and economic gap by focusing on the vast opportunities in technology for the Black Family, with information via the Web at www.ccgmag.com. This is a project of the Foundation for Educational Development. Factors recognized are:

1. African American children are not using computers as they should and are still driving in the slow lane of the Information Superhighway.
2. The average African American family income is still less than 60% of the average majority family's.
3. Unemployment rates are twice the national average and the savings rates are among the lowest of all groups in the USA.

3.2. Summary of Issues for Topic 2: Teaching K-Ph.D.

3.2.1. Back to Basic Needs: SMET Courses and Native Americans

It has been noticed that most reservation schools don't teach mathematics beyond Algebra I. Courses not offered include Trigonometry or even Algebra II, and, of course, Calculus. The tragedy is, that when these students reach college, there seems to be no way to catch up. If they take make-up classes their first year of college, usually tribal grants won't pay for those remedial classes. They are always and forever behind. Distance learning classes might be an answer for students who want these classes but are at a school that doesn't offer them. The Tribal Colleges are attempting to partially address some of these issues by partnering with local universities and consortiums, such as the National Computational Science Alliance. The schools may not be able to have full-time professors at their locations to teach these SMET classes, so partnering with Universities or other educational institutions that already teach these classes is one way to address the need. Of course, delivering these classes via distance education brings the burden of keeping a scarce technical person on their staff. Clearly, these are only partial

solutions. It seems that for Native Americans federal government involvement is essential. Unfortunately, not all tribes have satisfactory relationships with the corresponding state government. Treaty obligations give tribes a direct government-to-government relationship with the federal government, and it is this relationship that holds the most promise of providing technology solutions to the Indian country. This does not mean that states should not be involved, nor that private industry should not be tapped to help bring Native American people (and other minorities) from the back of the technology train to the front. But in the end Native Americans, practicing a policy of self-determination and self-direction, need resources, and the place those resources are most likely to come from is through the federal government relationship, not through the state. Clearly, Native Americans differ in this way from other minority groups, a question raised in another section. Through the American Indian Higher Education Consortium (AIHEC), the Presidents of thirty-one tribal colleges are acting in concert to develop a national strategy to develop the expertise and the computational infrastructure to become part of the information revolution rather than be victims of that revolution. One of the goals is to home-grow their expertise. At the same time, partnering with mainstream universities and industry in order to take their current faculty from where they are currently in their education and skills, and empower them to build expertise beyond that point through the development of internships, teaching, and apprenticeship efforts. A clear need is for distance programs at mainstream universities that can facilitate their current faculty to earn Ph.D. degrees (also with special funding for their academic work), or, Masters degrees in SMET fields. They will be faced with the temporary problem of doing without these academic personnel while they attend to their own development. A major point is that the solution to the digital divide has to come from the community in partnership with the federal government, private industry, and mainstream universities. It cannot come unilaterally without involving the communities they serve. One must point out that teaching mathematics is probably difficult at the best of times, even when students have the necessary background. One of the better tools for teaching is to have the students interact and discuss the topic. (Didn't someone wise in education say that students learn by talking and teachers teach by listening?) The web could help if better tools were available such as an interactive type of chat that allowed students to discuss K-12 mathematics problems easily. Unfortunately, most of the available software is not easy to use in that manner (as participants of this Cyberconference have surely noticed.) However, there may not be a good technology solution to offering math, or other technical topics, without a teacher on site. Interactive ITV and WWW pages, can favorably supplement teaching but having a person in situ for these courses is usually better whenever possible. An advanced degree is not indispensable for teaching beginning courses. Somehow many universities manage to use instructors with MS degrees going for a graduate education and with a penchant for teaching in freshman courses. They may compare favorably with some WWW-based courses in which insufficient time and money has been invested.

3.2.2. Technology and Connectivity; Parental Involvement

The most important use of information technology today is to improve education for all students, and we have a great opportunity to enhance the ways we think and learn by taking advantage of computer-based technology (CBT). Electronic education within a connected learning community in which all students have access to the world's information through personal computers, and educators, students, parents, and the community are connected to each other, should be researched and be an ultimate goal of IT. In this process, educators and parents

must be involved. Business and government entities find it easy to offload increasing amounts of research on the universities, but they also must take their share of the responsibility. Are there any aspects that could be investigated/developed where CBT might be particularly beneficial to underrepresented minorities? How do current minority skill levels compare with those of others for successful completion of a range of CB technology areas? Will current CBTs have to be adjusted in special ways for minorities? Is simply using CBTs sufficient to stimulate an interest in IT areas? New multimedia technologies offer enormous educational possibilities in the Internet, but technology-capable parents, with the collaboration of their employers, could help the teachers learn how to take full advantage of it. Learning to use computers to support classroom instruction is daunting for many classroom teachers, and is just as important as having the hardware available and functioning. There is a need to study this problem and identify ways to provide the support in-service teachers need to become competent in (1) using computer hardware, (2) using software, and (3) integrating this technology into instruction in meaningful ways. Model approaches are needed for the national solution of these problems. There is some anecdotal evidence of some good results from in-service courses from the University of Minnesota-Duluth. No less important is involving parents with the skill levels in the training, for those who can, but there is also the aspect of training those parents who have no idea what their elementary school children are talking about when they come home at night and tell their parents what wonderful things they can do with technology. Some Houston, TX, schools have gone to an extended day (until 8pm) for parent instruction. Similarly, Wright State University College of Engineering has a pre-college Science, Technology, and Engineering Preparation Program where involvement of parents of inner city 7th. to 10th. graders is required at orientation meetings and at career awareness workshops where they learn about the program, engineering careers, and opportunities for their children if they choose engineering or computer science as a major. All parents attend because the scholarship for their child depends on them being supportive.

3.2.3. Well Applied, Relevant, CBTs can help Minorities

The CBTs are a great help in teaching technology, but just making them available, i.e., distributing through an Internet web site, isn't the answer. Were it as simple as that, then the rural schools, as most urban schools, would be able to participate in all the technology available today. But it isn't that simple. For the most impact and acceptance, and for impressionable and acceptable usage it is suggested that CBT web pages be relevantly customized to include appropriate motifs and icons, including stories that can be used by the student to relate the project to his/her experiences. This design could also include a log area at the end of each page, which would include a section that would help the student write how each exercise is relevant and could be used in his/her environment. It may take some help from the instructor for the student "to take it back home," to see the relevance of such as for example "pointing out that to design their VR model, they had to formulate the contents, the process, and the actions for their model to work. If they were modeling a pasture, they would have to design the fence, decide what materials are needed, decide how much was needed, and where it was going. Can they take that knowledge back home and use it? Of course." When looking at the benefits that technology brings to education, research is needed on how learners of different ethnic, sociological, geographic, and economic groups can take best advantage of it to learn and assimilate information.

> *"Students simply do not see the urgency in developing proficient computer skills…"* —Craig Evans

3.2.4. On Recognition of Teaching and on Teaching Minorities

Several of the problems in valuing teaching vs. research and publications are present in predominantly minority institutions as well as they are in most other institutions. Unfortunately, but their results are even more devastating in those institutions. This is because it discourages faculty from paying attention to the primary function of any educational institution. What makes the issue most tantalizing is that this is in fact imposed most of the time by the faculty Promotion and Tenure Committees. Why is it that we, as a community of professors, do not seem to be able to give proper recognition and rewards to good teaching but find it easier to justify rewards for research dollars or publications? Is it because grants and publications are easier to quantify than good teaching? Perhaps we should consider more awards involving teaching issues/methods in IT, particularly where underrepresented minorities are concerned. However, in institutions using a seniority pay scale (often negotiated by powerful unions, as is the case at many public K-12 schools) the rewards for quality/productivity in teaching/research are irrelevant. It would be interesting to understand minority attendance to 2-year (where research is minimal and teaching loads are high) vs. 4-year institutions.

3.2.5. Comparative Cost of SMET Curricula

If we compare the cost of IT and related SMET courses with other programs such as Law Enforcement, we not only have the cost of expensive teachers for CS, but we do not require expensive laboratories, just classroom space for Law Enforcement. Yet tuition and other credit-based sources are similar. Faced with this dilemma, a minority institution with meager resources, faces hiring the right faculty for a Law Enforcement program vs. hiring the right faculty and building appropriate physical science *and* a computing laboratory infrastructure for a Computer Science program. It is difficult to criticize institutions for having meager SMET infrastructures when they are living on the edge of paying current expenses. Can we require differential tuition and subsidy for expensive SMET courses?

3.2.6. "The Pipeline" - The Graduate School Branch

One of the real declines in IT is in the number of students applying for graduate work during a booming technical economy. The OGI Graduate School has established a web site that attempts to explain the basics about Graduate School. The site in intended as a resource for the Computer Science Community and they welcome feedback and suggestions for improvement. To attract new graduate students it is also suggested to schedule an evening with home current graduate students and members of your faculty with graduating seniors to whom such information and opportunities in grad school are presented. These modest steps may help in disseminating information rather than just lamenting the lack of enrollment.

3.2.7. Distance Education

Internet Courses for Advance Placement - It seems that Universities are using the Internet mostly as a backup and supplement to classroom instruction, but not as a stand-alone teaching tool. While at present stand-alone Internet courses are still crude, there is no question that they could be improved possibly to the point of competing with classroom courses if enough attention is paid to them (this is particularly true in “value judgement” areas like Business Administration but not so easy to implement in technical areas!). In particular, they would help tremendously in

continuing education and lifelong learning. If minorities lacked access, greater disparity would occur.

3.2.8. Selection of IT Careers by Capable Minority Candidates

Selection or encouragement of candidates for IT in post secondary school is often done by testing candidates or sampling IT students for interest in the computing and information sciences. Students enroll in introductory classes in HS or after on basic computer concepts, and often selection of the future major was strongly influenced by such introduction, although no one is denied the opportunity to choose any major. While the success of the students in those introductory classes is high, their retention for choice of a career is not. Unfortunately the presentations in such classes are not the most inspiring and the textbooks do not cover what the students consider exciting topics such as developing web pages, networking, and popular programming languages like JAVA. Recruiters and companies look for these skills in potential employees and the perception of the students is that those are important skills in gaining employment. The influence of employers in attracting students to IT is real, and they should have their say in curricula that include the skills needed for employment to maintain interest and retention in IT.

3.2.9. Relevancy and Education

"Relevancy" means that the students can incorporate their academic experience within a related direct personal experience in their lives. Teachers and professors, who teach how to learn, think, and apply research skills, and who inflame the student's imagination do more for them than any particular course of study. However, we do not emphasize those aspects in classical education. We need to teach the students how to leverage scholastic skills to change with the times and learn on their own in their lifelong learning path.

> *"The teachers and professors, who taught me how to learn, think, and apply research skills, and who inflamed my imagination did more for me than any particular course of study."* —Thomas Taylor

It is unfortunate that some influential educators, such as a past Secretary of Education and author, William J Bennett, in his book "The Educated Child," do not include information technology, even at a literacy level, among the desired topics except briefly as classroom enrichment. Other classical areas of knowledge discussed in that book were English, History, Geography, Art, Music, Mathematics, and Science. Mr. Bennett seems to believe that computer literacy should not be a fundamental subject until the middle school years at best. In fact, he felt it would be distracting until a student formed critical thinking skills from a strong core curriculum. Since many elementary schools are using computers, research is needed to answer definitively the question of where is the most appropriate point in the K - 12 continuum to begin the introduction of IT skills and to foster the motivation to pursue this area as a basic skill for all students capable of handling lifelong learning and a rapidly changing technology.

Because the subject is still relatively new in the classroom and for many teachers, it is not being incorporated except as an educational tool and only in those environments where the facilities exist. The result is that many students are not even aware that careers in computing are an option in their lives and that they may have the prerequisite education (or can acquire it) to become part of the IT industry as a professional. It is not too early at grade school to show the

relevancy to their own culture, future and community development of such important subject. This is particularly true in minority settings where the facilities do not support other uses of computers even as purely educational tools.

3.3. Summary of Issues for Topic 3: Research

3.3.1. U.S. citizens and Minorities in Graduate School

There is a clear trend to go into industry and not to graduate school, at least not on a full time basis, for citizens of the U.S. This trend is particularly exacerbated by the industrial needs in a thriving economy, and especially in the SMET disciplines to the point that we could think that we are eating our "seed corn." We see high-school graduates who have beginners' knowledge of the field, being lured to industry. How far can their self-education carry them? How much remediation will they need later on? A model for Graduate School cooperative education is being designed and considered successful at Georgia Tech. The impetus to attend graduate school is helped by an economic incentive for US students where the equivalent salary of BS in industry equals a fellowship plus co-op opportunity. It seems that the factors are economic and the pressures are social. Many employers pay tuition while the students go to school on their own time, so why should the students pay out of their own pocket when it seems that they could both work and go to school part time? The problem is that working a good eight hours and going to school afterwards is very difficult and the practical experience gained is sometimes lost in lower academic performance. Social pressures (marriage, young children, and the ambitions of upscale living, among others) discourage the monastic life of a graduate student. The worst trend is that employers are now luring high school students who know some computing (minorities and not) to go to work, thereby shortchanging future opportunities. How can universities compete? Does it make sense to try to subsidize industry to give time off to graduate students so that they "co-op" and go to school? At the University of New Mexico's - Albuquerque High Performance Computing Center both undergraduate and graduate student Research Assistants (RA's) are hired to directly addresses the 'retention' problem. The hiring process 'rewards' the students as they get higher in their education. Undergraduates receive a small per hour wage, the Masters level students receive a higher per hour wage and the Ph.D. students get the best wage. In that manner, they are rewarded the more they advance academically. Also with a 20-hr/week workload, they are not overloaded with work and can concentrate on their studies. Graduate fees and full tuition are covered while they are RA's, and during the summer they are hired for 40 hrs/week, thus keeping them for the following semester without worrying if they will return. However, there is the question of numbers. How many students can we afford to employ? Even with such incentives, there is a significant dropout in going from the undergraduate to the graduate level. Potential graduate school students go to businesses. While working at the Albuquerque Supercomputing Center looks great on the student's resume, it cannot compete with the National Laboratories in NM and large business enterprises. If the students become excited about their research in the graduate program, then they usually complete the MS and Ph.D. program. Getting them to continue after an undergraduate degree is another challenge altogether.

It has been pointed out that, even if all the available "seed corn" were planted, we would, as a nation, still face the big problem gleaned from the Taulbee Survey data. For the years 1990-1997, sixty-six African American Ph.D. degrees were awarded in computer science and engineering, which translates to an average of 9.4 per year. Even if all of these went into

academic careers, at most, nine out of the several hundred possible departments could hire a new faculty member who was African American. As it is, 90 percent go into industry (see "The Supply of Information Technology Workers in the United States" from the CRA) so realistically only one department per year could be hiring. For Hispanics, the numbers are somewhat more promising, although still proportionately low. For the years 1990-1997, the Taulbee Survey reported 123 Hispanic Ph.D. degrees awarded in computer science and engineering, which translates to 17.6 per year, on average. Still, even if all of these went into academia, only 17 departments could be hiring them. For Native Americans, the situation is not good. For those years for which the Taulbee Survey reports Ph.D. degrees awarded in CSE to Native Americans, 1993-1997, the total number was 6, or 1.5 per year on average.

3.3.2. Is it "rewarding" to go to Graduate School in IT?

When recruiting minority students for Ph.D. study in CS, it is hard to explain why a student should go to school for an additional five years and then - as a faculty member - typically earn about the same that he or she could earn now with a BS. We could stress to the student the fundamental beauty and exciting new interest of the fields, in contrast to motivating graduate study through communicating practical value to industry. If one is going to make CS research one's life's work, it is best if one really enjoys it! And, since academia will have to compete with industry for Ph.D. graduates for the foreseeable future, we should be looking at ways to bring academic salaries at least into the same ballpark. One way to do this, if industry understands the "seed corn" argument, is for industry to fund substantial endowments for CS departments at minority institutions where they seek employees. However, appealing to prospective students on the basis of the satisfaction, expertise, and in-depth knowledge that comes from graduate study alone, has not been successful in every case. It is hard to compete with "big bucks" and the freedom (from the hard and seemingly unrewarding work that is graduate study) that industry has to offer. Most likely, there is no "silver bullet" solution to this problem. We must use a variety of approaches, some of which have already been identified in this dialog.

Perhaps the long-term solution requires for us to learn how to stimulate a renewal of curiosity and a thirst for knowledge among pre-college students. It seems that many students begin to work before college, they begin to have "good" money, a car, etc. and they (wrongly) think they do not need to study anymore. Work has to be done among pre-college students "to open their eyes" to a vision of their own future personal development. Humans are innately curious, but at times are taught not to delve deeply into a topic. Curiosity, the first key to do research, needs to be nurtured and celebrated. The survival instinct tends to overshadow curiosity as one matures, which is contrary to the fact that to do research one requires free time to think. This is not possible if one is concentrating on surviving. Understanding that one could survive is influential in deciding to pursue a Ph.D. degree. Perhaps curiosity can't be taught but when it exists it can be stifled by poverty, hunger, and indifference. For those who are curious in their early years, steps must be taken to encourage, promote, nurture curiosity which when fulfilled, probably leads to more curiosity -- to paraphrase, we've got to begin at a very early age.

The type of person who has "traditionally" enjoyed research had a persevering nature and was capable of conducting one failed experiment after another until finally getting the theory and the experiment right. Leaders in modern corporations, on the other hand, typically have very short planning horizons, and academic administrators are not far behind corporate America in

this regard. It is now often difficult (particularly in CS/CE) to distinguish between academic research and industrial research. This trend is exacerbated somewhat by the emphasis of funding agencies on incremental results. Because there is a proper and large engineering component to computer science, it is easy to fall into the short-term technology trap. Because universities are being forced to run more like businesses, we are seeing similar trends there. How do we interest young people in general, and minorities in particular, in research careers? Some suggestions are:

- Find or nurture people who are not deterred by repeated failures before achieving a success.
- Help universities distinguish academic research from industrial research. e.g. - figure out what it is that Lazlo Lovasz can do at Microsoft that he can't do at Yale.
- Develop some laudable national or global goals that require long-term research - e.g., putting a person on the moon, feeding the hungry, clean air, etc.
- Develop and deploy some charismatic proselytizers.

3.3.3. Affirmative Development

A recent report of the College Board promotes an "Affirmative Development" campaign (see http://www.collegeboard.com/press/html9900/html/991017.html). The most surprising result of this study was that the socioeconomic level was not a factor for underrepresentation of minorities among high achievers. The underrepresentation occurred at all socioeconomic levels of students. In other words, contrary to expectations, underrepresented minorities at low socioeconomic levels were not less present than those at high levels among top performers. Of course, this does not say anything about average or below average performers. The report recommends:

- Supporting efforts in primary and secondary schools, including the development of a common database of resources, information, and promising intervention strategies.
- Organizing a consortium of colleges and universities to promote and evaluate the use of promising approaches for helping underrepresented minority students achieve at higher levels.
- Forming collaborations with community organizations, religious groups, and minority associations outside of the school setting to ensure that they promote high achievement through supplemental educational opportunities among young people in their communities.
- Promoting additional research projects to understand the causes and dynamics of academic underachievement in some groups of minority students - which is what we are doing in this Cyberconference.
- Convening a multi-disciplinary panel of experts to continue exploring new ways to improve achievement among minority students.

While the emphasis of the report is on high achievers, because they are visualized as leaders and role models, these approaches should hold also for minorities at all other levels of achievement.

3.3.4. The Pipeline Model and Its Implications for Minorities with Undergraduate Degrees

A "Workshop on Increasing Participation of Minorities in the Computing Disciplines" took place at the Airlie Center in Airlie, VA, on May 4-7, 1995, under the chairmanship of Bryant W. York. The conference was preceded by a set of position papers submitted by the participants. One of the concepts discussed was the comparison of the education of minorities to a leaky "pipeline." The pipeline is looked upon as the sequential feed-through of the educational system from kindergarten to doctoral programs (K-Ph.D.). In particular, the questions addressed relate to what are the social, cultural, and educational factors that may be brought to bear to stop the "leakage" of underrepresented minority human capital. Much has happened since (or has it not?) but the prospect of a wider pipeline is not forthcoming. While we don't have undergraduate enrollment figures or know the career choices of current secondary and elementary school children, we can only hope that the pipeline is already fuller in the earlier years, although the lack of an upward trend in the Taulbee report numbers for graduates would suggest otherwise. If it is the case that the pipeline remains yet to be made fuller, and if contributors to this Cyberconference are correct in saying that critical support needs to come as early as the first years of primary education, then we won't see significant increases in the minority population of potential IT leaders for about twenty years. That's the best-case condition assuming the steps we take now are effective. This suggests consideration of a significant effort to encourage older members of minority groups already with undergraduate degrees to return for graduate study in IT. Such a policy, if successful, would create new within-community IT leaders in five or six years instead of 20.

The output of "the Pipeline" has already run dry based on the statistics from the Bureau of Labor Statistics which estimated a 118% increase expected from 1996 to 2006 in demand for database administrators, computer-support specialists and computer scientists, particularly when compared to the data from ACT which indicated 4% of 1999 ACT-tested graduates planning will go into computer and information science. Of the 53 million children in K-12, some 47 million attend public school. Only 1 in 9 are enrolled in private schools or about 2% of the population. Since in 9 out of 10 cases, non-minority students (88%) attend public schools and that typical public school student is the middle-class child who makes up the large majority (64%) of enrollment, the reality is that K-12 school failure crosses all racial, ethnic, religious and socioeconomic lines, affecting every area. Universities and colleges of engineering/information science and computer science need to redesign the K-12 educational pipeline by implementing across-the-board pre-engineering/pre-information technology/pre-PC summer programs and camps to refill the pipeline from a dismal 4% to a value that equates better to demand, say 15 to 20%. Failure to properly educate American youth has forced us to rely on the outside world for technical expertise. Much of Corporate America is "raiding the seed corn" as a naturally selfish knee-jerk response to a larger underlying socio-educational problem which begs to be fixed.

3.3.5. Who will lead from within our communities?

Although the prospect of encouraging older members of minority groups to return for graduate study has potential, it poses the problem that once they've been out for a number of years, it is much harder to return: family and work responsibilities, financial commitments, severe financial sacrifice, eroded technical skills, and so forth. However, there may be a possibility to recruit minorities into the field of technology such as the military or from less advanced positions in industry, if they have the necessary talents and incentives. It would seem

more likely that people already with baccalaureate or AS degrees in IT could be encouraged to continue their education.

3.3.6. References and priorities

Some references that contribute to the knowledge base of understanding how technology affects/operates along gender and ethnic lines in academia:

- Spotts, T., Bowman, M.A., & Mertz, C. (1997). "Gender and use of instructional technologies: A study of university faculty" in *Higher Education*, 34, 421-436.
- Okpala, A.O., & Okpala, C.O. (1997 December). "Faculty Adoption of Educational Technologies in Higher Learning" in the *Journal of Instructional Psychology*, 24(4), 262-67.
- Rifkin, J., "Technology and the African American Experience" in The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-market Era, New York: G.P. Putnam's Sons, 1995. Book chapter (outside the context of higher education).

Higher Education seems like a very male and white oriented environment, particularly in administration. How does one find out the most effective approaches to diversify Higher Education -and other educational environment- throughout the nation, particularly in IT and SMET topics? The emphases are on prioritizing what would have the greatest impact and on determining the methodologies to get there.

There seems to be a significant group of knowledgeable people who believe that the so-called "Digital Divide" is due primarily to socioeconomic causes and is much less due to race and ethnicity. However, the College Board study cited elsewhere, indicated that the underrepresentation among high achievers by minorities was the same across all socioeconomic boundaries. This does not mean that the same is true for the "digital divide" but it raises some interesting research questions.

> *"The so-called Digital Divide is due primarily to socio-economic causes and is much less due to race and ethnicity. On many occasions since, others have expressed the same belief."* —Mario Gonzalez

From PBS's "Digital Divide" we quote: "Computers are increasingly conditioning the kind of country we live in. DIGITAL DIVIDE shines a light on the role computers play in widening social gaps throughout our society, particularly among young people. By providing equitable and meaningful access to technology we can ensure that all children step into the 21st Century together."

Studio Miramar produced this video, titled "Digital Divide," for the Independent Television Service (ITVS) with funds provided by the Corporation for Public Broadcasting. There are four sections of the corresponding WWW home frame (http://www.pbs.org/digitaldivide/) referring to the classroom, to gender, to race and to work. Each of the four sections has three parts: one dealing with a simple interactive quiz, another with interviews of some four people relevant to the topic, and a third one is a set of web references. Some of the issues covered in this Cyberconference are mentioned and others are not even considered. The program will be aired on January 28, 2000.

3.4. Summary of Issues for Topic 4: Mentoring

3.4.1. Who and How Many? How do we scale up? Who can mentor? What is a critical mass for peer mentoring? The efficiency of peer mentoring

Peer mentoring, among the non-traditional forms of mentoring, has a crucial role to play in supporting minorities, as exemplified by support from experienced members of the same or different ethnic group. (A peer is simply someone who has a close rapport with a mentee and is considered on the same or a slightly higher academic level. Student-to-student mentoring is peer mentoring, just as faculty-to-faculty. If the students can develop a "personal, caring, and responsible relationship" then peer mentoring can occur.) The University of Texas at El Paso has obtained good results with peer teaming and mentoring. For schools that don't have significant numbers of graduate students from underrepresented minorities, the graduate experience is probably awfully lonely (see below). Yet it would be an unacceptable policy to steer students only to schools that already have significant numbers of minority students. It is important to note that one can have more than one mentor. Each mentor can serve a different purpose. In some instances, the mentor may or may not be in the same department or program. It seems that the mentor should be someone who cares and has high expectations for the mentee. Someone who can be supportive of the best interests of the student and the community even without necessarily enabling them. It is worth remembering, however, that all mentoring is not positive.

> *"I found a great benefit from peer-mentoring. In 1991, I participated in the Summer Research Opportunity Program…"* —Quelina Jordan

Issues like thriving vs. survival in the mentee's organization/environment could certainly be mentored by someone in a different specialty/department. And it may actually be healthier for the student to have a collection of mentors for different purposes so that the student doesn't feel totally dependent on a particular teacher or administrator. A common difficulty is figuring out if the student's problem is more serious than simply his/her lack of confidence.

Could an organization or center be started to handle mentoring via e-mail? A group of capable and possibly trained mentors would have to be available. How could we possibly certify the qualifications of a mentor? How do we evaluate what makes a good mentor? And then, if we knew that, could we possibly grow good mentors! Mentoring requires fairly intense interaction between the mentor and the mentee. The problem is that there are simply not enough mentors available to make a significant impact, which is particularly true if mentors must be of the same ethnicity/sex as the mentee. How can we deal with this issue? The women's groups have instituted a distributed mentoring system that uses email plus summer visits. The minorities' case may be even harder.

Some of the goals in mentoring are to provide information, support, and guidance and that is different at different levels. On the Ph.D. level, most of this support has to do with teaching someone how to do research and how to thrive in an academic environment. The information part can be done by email. The trust part, which develops the relationship, has to be done in person. Additionally, there are a host of habits to be learned by just seeing them occur.

3.4.2. Isolation of Minority Students

It is reported that underrepresented minorities have a sense of cultural isolation in non-minority institutions. Some of it could be alleviated with minority news groups and reaching out to other minorities, possibly not in the same major or career-path, to receive encouragement or special personal advice. (One such newsletter is the "Minority Leaders Newsletter" published by The Multicultural Advantage with its web site at http://www.tmaonline.net. Another list is the Minority Internet and Technology Professionals or MITP at www.mitp.net or www.mitp.org.) Few institutions (especially graduate degree granting) have a critical mass of underrepresented graduate students to develop a strong peer mentoring system. Thus, if peer mentoring were to take place on site it would have to involve some cross ethnic mentoring. Of course, electronic peer mentoring can bridge part of this gap - at least for some learners. Associated questions are: Are there documented examples of successful electronic peer mentoring? Is there research documented or being carried out evaluating the success of this approach? Might there be mentors who can actually work their magic through the Internet?

3.4.3. Can we teach/learn how to be a mentee or mentor?

A Mentoring Course: The traditional role of faculty has been to teach and advise students. Mentoring is different and more important than either of these roles, particularly when it comes to increasing the number of minorities in Information Science and Technology. In general, faculty are already overburdened, and especially at public schools in the inner city and at Historically Black Colleges and Universities (HBCU's). An approach to consider is that of designing a one credit hour course for mentoring students majoring in an area of Information Science and Technology. Students should be assigned homework to:

1. research their career areas of interest,
2. research general issues in the field of Information Science and Technology,
3. find what the opportunities are for career growth and personal development in IT,

and other similar questions. This could provide for structured mentoring, thereby ensuring that all students are mentored to some extent without adding significantly to the workload of faculty. Associated questions are: Is there a place for such a course in the public schools, if so at which grade level(s)? Is there a place for such a course in undergraduate curricula, if so at which level? Would the cost be prohibitive? How could costs be mitigated? Can the issue of academic quality/content be satisfied for awarding one credit hour for this kind of activity?

As we discuss how to mentor, we should consider how to be a mentee. How is one prepared to be a mentee? Is there something in the educational process that can prepare people to take advice from who could be a total stranger? How does one choose/trust a Mentor? Could this be incorporated in an orientation/boot-camp program?

3.4.4. Motivational Mentoring/Career Guidance?

If we are to succeed in our goal of increasing the number of underrepresented minority students pursuing professional careers and/or graduate studies in Information Science and Technology we need better motivational mentoring for K-12 students and for undergraduate students. Students are well motivated when they understand how their studies pertain to practical problems and issues in industry. This understanding enables them to evaluate their

progress toward a professional career. K-12 students should have exposure (if only discussions) to the types of problems they might encounter at an undergraduate level. Undergraduate students should have exposure to practical problems that are encountered in industry and/or graduate studies. This exposure can be in the form of informal discussions: one-on-one or small groups, seminars, field trips, or internships. What role would professionals in industry play? What role would faculty at the graduate or undergraduate level play? Which technology issues could be motivational as well as inspirational for the targeted students?

3.4.5. Apprenticeship and Mentoring

Student or Research Assistants are, in a sense, mentees who should be subject to positive comments and proper guidance on their efforts. With some additional care, the teaching/research assistants can be apprentices to whom we can provide additional insights and understanding about the field of Information Science Technology. This is not unique to underrepresented minorities, but it applies there with more impact when we emphasize attracting and retaining minorities in the IT workforce. In addition to Work Study, Internships, Student Grader, Teaching or Research Assistants, there are other similar activities where a student can serve as an apprentice, thereby gaining practical experiences under the guidance of a professional in the field of Information Science. Is there a sufficient number of apprenticeships/internships available? How could additional funding be provided to support this kind of activity and give it a mentoring flavor?

3.4.6. Mentoring Minorities to Graduate School through REUs

Getting undergraduates involved in research (Research Experiences for Undergraduates) is one of the ways to get minority and women students directly involved in faculty research projects. Such a program is supported at Ohio State by the GE "Faculty for the Future" fund, and one of its keys is that there are faculty incentives: modest discretionary funds and free undergraduate research assistants. It has resulted in nearly all of the participants ending up at least seriously considering going to graduate school (most applying with an edge because they have been involved in research already). This is one way to overcome the perceived "cost" to faculty to get involved in mentoring. While it doesn't immediately solve the problem of not having minority faculty to do the actual mentoring, it potentially helps with that in the long run, because it makes it more likely that minority undergraduates go on to graduate school, and then to faculty positions (see http://www.cis.ohio-state.edu/diversity/).

While mentoring and REUs provide encouragement to go to graduate school, some of the nurturing that takes place in a small school may not fully prepare students for the impersonal, sink or swim climates of large graduate programs. Nevertheless, surveyed respondents who encountered this situation were still able to get advice from their undergraduate mentors as to how to persist in the program. We could benefit from the input of some of the recipients of the AAAS and White House Mentor Awards. We can probably gain considerable insight from mentees from successful programs like the one at Rice University and the Meyerhoff Program at the University of Maryland, Baltimore County.

3.4.7. The Pyramid of Mentoring

At Rice University, an approach called the pyramid of mentoring is used. The senior graduate students mentor those more junior, and the junior graduate students mentor the

undergraduates. The role of the faculty mentor is to go in on an as-needed basis when this structure needs intervention. Sometimes this is with the student directly, and sometimes it is as an advocate with either departments or administration. This is an extremely important part of Rice's retention program. This program was evaluated by the UW-Madison's LEAD Center two years ago, and the report may be found at

http://www.crpc.rice.edu/CRPC/newsArchive/sas_eval.html.

The Pyramid approach distributes the mentoring load. A person who needs or wants help needs the solution while the source of the solution, as long as it is a good one, isn't as important. The law students at Northeastern also use a pyramid of mentoring approach that has worked well for at least 10 years.

3.4.8. Research on Mentoring in Academia

It is a fact that there are, in general, not enough minorities to provide serious mentorship at major institutions. Is it wrong to presume that only a person of the same ethnicity can serve as a mentor? The presence of minorities, few as they are, in professional life or educational institutions could be seen as indicating that either some mentoring has occurred or that, if the minority student has not been exposed to mentoring prior to enrolling in a graduate or Ph.D. program, he or she has already become fairly self-sufficient. The concept of seeking out a mentor for assistance and guidance may be alien and somewhat repugnant to some in that it might imply that person needs assistance. Even when mentoring is offered, the student may not realize that the intent is genuine and usually needed. What are the views of the students? Research on mentoring so far has been studying the instances of successful mentor/mentee (those who have successfully completed their programs and gone on to visibly successful careers) and anecdotal success stories, but we should also study those former students who reached a level where they should have succeeded but failed. An example of such an instance may be where a percentage of course requirements plus GPA would normally predict a high probability of success. Yet the student has dropped out of the program or is ABD. We should investigate failed cases, possibly due to a lack of mentoring, including the percentage of students who have completed all the requirements for advanced degrees except for the completion of a thesis or dissertation. This is not just a minority issue, but it would help to determine what effect mentoring had on the academic experience of the students on a comparative basis.

3.4.9. Mentoring as a Topic of Research

Which mentoring techniques work best at the undergraduate and which at the graduate levels? In Computer Science mentoring is often combined with tutoring and with help sessions in the core IT courses, lectures in time management, and in remedial work. At the graduate level mentoring is frequently combined with help in improving communication skills and creating plans of studies including selecting thesis and dissertation topics. Peer mentoring by advanced minority students together with the right faculty could provide a structure to mentoring to those new students entering the programs. An objective study of the efficacy of mentoring methods could provide help to students and mentors alike. Objectivity and generalizations are difficult because successful mentoring requires balancing the personalities of mentor and mentee. Most of the time this balance happens in a natural, haphazard, and less than organized way. It is not easy to project the most effective and efficient way to do mentoring. There are too many variables in the equation to be able to provide a ready-made solution. Empirical research of

mentoring, while difficult to conduct, is important. Given its importance to IT manpower development, it might include a study of any particular characteristics of IT mentees that relate to special mentor attributes. A how-to handbook would be difficult for the "encouraging, you-can-do-it" type of mentoring. The quality of the relationship between the mentor/mentee is a critical factor. Trust is fundamental. How do you teach that? Yet some analysis of the mentoring practices most successful with underrepresented groups would be very helpful.

3.4.10. Study Mentoring in a Social Context

Mentoring is best described by keeping track of the emotion that an advisor evokes in the mentee after different types of interactions. Beyond the understanding obtained by coldly analyzing the facts, there is need to understand the emotions after interactions, and consequently the support felt or not felt. That emotional context can only be fully understood by understanding who the mentor and mentee are as persons, and what is the environment in which they operate.

Observation: Individual Mentoring occurs in the context of larger social dynamics

Proposal: Study how people close to the mentee affect the mentoring process.

Validation by a peer group of advice given by a mentor is extremely helpful within a mentoring relationship An advisor's suggestion for a plan of action and sharing it with the mentee's peer group (people with similar goals who support the suggested plan) results in a healthy complementary pull/lead by the advisor and the push/support of the peer group. What other social dynamics facilitate the mentoring process is definitely a research question for the social sciences.

Mentoring is essential for guiding minorities, particularly when the students don't get guidance, advice or support from parents or siblings. It seems essential to advise these students of the hurdles they need to surpass, such as the disadvantage of competing with others whose background is stronger when entering a majority school, to restore the self-confidence that is crushed when trying to compete with such students, to advise them that there may be a gap that requires taking remedial classes, and that such is not due to the individual's lack of intelligence.

3.4.11. Can Mentoring be Successful in Any Kind of Institution?

While research-oriented institutions concentrate on rewarding the influx of grants and awards, the question is raised with regard to whether institutions not oriented toward research can take the mentoring idea forward in place of putting emphasis on research. It turns out that the dichotomy is not so simple. Many institutions, which would not be considered "research universities", end up rewarding research and others recognized as research institutions emphasize mentoring and minority enhancement programs. No university would ever admit that they *do not care about human development* even if they are indifferent to issues of mentoring. But often the tenure and promotion process, carried out by faculty, is where the neglect takes place. Could we imagine a line in a Promotion and Tenure application form that reads: "Explain how you have mentored and thus contributed to the human development of the students you advise?" The fact is that the "incentives" to mentoring in our universities are few or non-existent. Faculty members do it only because they feel that it will benefit the student - they know full well that promotions and tenure are unaffected by it. However, universities react promptly to incentives by government funding sources and such could be used to promote change.

A topic of interest in the research sociology of IT would be to find out why some graduate students continue into research careers and others don't. What are the factors that influence this? How does the environment affect the decision?

3.4.12. Methods of Mentoring

There are many ways to accomplish mentoring and motivating students. For example, "job shadowing" allows an IT Professional working in the field to mentor a minority HS/College by demonstrating on-the-job examples of various assignments in the field at the rate of a day a week for 10 weeks; paid internships or co-op programs for the summer allow students to interact on a hands on basis to apply theory learned in the classroom; and, computer camps, established at various colleges where the IT professionals can interact with potential minority students trying to learn more about the IT field. There is a question, so far unresolved, about the most desirable ethnicity or gender and what can be done if a mentor of the same minority group or gender is not available (we may not have enough mentors!). There is need to make the connection between the student's interests in employment and corporate expectations. Unfortunately, at times this leads more to training than to education. But mentoring by industrial professionals can give a different perspective for the student from where to choose and increase interest and retention in IT. Variants of the paid internship and co-op programs, such as computer clubs, may provide important experiences to the students. While job-related issues are important, they should not totally overshadow "relevancy;" this means that the students are able to incorporate their academic experience to a related direct personal experience in their lives. There were some other previous comments with regard to the use of graphics in a Native American school that addressed this subject. Relevancy is necessary, even possibly indispensable, to make the learning taking place be remembered by its meaningfulness to the student. The idea of jobs and the job market does not hurt in motivation, but at times it is like chasing rabbits in an ever-changing technology like IT. The examples of "Computer Olympics" by the BDPA above can also provide a motivational and retentive experience.

> *"There are technologically inept mentors for the next generation as we continue to expect technological competence from the mentee."* —Heidi Lovett

Mentoring on campus is typically limited by the realities that many professors, under heavy teaching loads, don't have the time to devote, in addition to teaching, to reaching out to the students and spending additional time on campus clubs. External business or technical organizations supplement campus life with outreach/give back programs and projects.

It may be counterproductive to expect that a mentor must be of the same

> *"…individuals in the corporate environment have been told all their lives that the pathway to success is having a good mentor. However, when it comes to dealing with race and gender there seems to be a problem for individuals in finding a mentor. I don't think we should limit who is mentor by the fact that they are not of the same racial group or gender of the individual that is seeking help. The IT world is still a world that is dominated by white males, and those of us who are of color are going to have to learn how to operate effectively in that world to be successful. We are going to have to understand how to ask for and accept help in any form or shape it comes in. We need to teach our students that it is ok to ask for assistance because that is the way to learn…"* —Timothy Wilson

minority group or sex. In a world of IT majorities it may be a good experience to be mentored by one of them if it leads to learning how to be effective in that world. A part of it is to find out how to ask for and accept help when needed to learn new things. "Teach that to learn (or to be mentored!) one has to ask for help from anyone, regardless of sex or race." There are just not enough minority or women mentors to go around and cross-boundary mentoring breaks down some of the barriers in a pragmatic way.

IT can promote itself and serve in mentoring at the same time. On-line courses, seminars and workshops that the students can access enables them to find out what kinds of opportunities exist in the field. any students (and faculty) still do not have a full appreciation for what IT is or involves.

3.4.13. Financial Goals and Realities

It has been pointed out that while there is a strong financial motivation in many career choices, it is not the only, and at times not even the strongest motivation. Although everybody has corporate expectations, not everybody goes to school or chooses their career with the sole intention of making the most money from it. If that were the case, there would not be Music, Anthropology, or History of Arts.

Even in internships and co-op programs, while they are important, the student does not always have to get paid in order to have a valuable experience. Computer clubs at Universities can also be a beneficial experience, particularly if other internships or co-op programs are not available, as it allows one significant entry in the resume or portfolio. However, internships that do pay allow not only for spending money but also to purchase the tools needed to stay in the computer field.

> *"Let's face it, the majority of our students can't afford internships that don't pay..... and this isn't just to have spending money, but to legally purchase the tools needed to stay in the computer game..."* —Bonnie Bracey

However, there is a certain amount of social pressure by the popular press and the marketplace which is reflected both in the attraction toward IT and in the anxieties of parents, students and faculty to have their students employed at the best possible salary or obtain significant financial success.

3.5. Summary of Issues for Topic 5: Other

3.5.1. Different Issues for Different Minority Groups

The relative success of some underrepresented minority groups in some aspects of life over others indicates that possibly there are more than just cultural biases in the problem. It has been pointed out that we should differentiate between having similar problems from having similar symptoms and that obstacles to technology are uniquely different for different minorities. One would be the value of technology in the mind of different minority groups. Economic and cultural issues may be disclosed in a macroeconomic sense by looking at the purchasing habits of the groups and their correlated academic achievements in education in SMET and IT.

3.5.2. Public Education and IT Proficiency Demonstration

The book "Conspiracy of Ignorance," by Martin L Gross ISBN 0-06-019458-8, c1999, Harper-Collins Publ., is recommended for educational reformers before attempting changes in public education and it's impact on minorities participating in IT. Quality management and Pareto analysis would suggest researching each minority group and determining the common elements and tackling those problems under the 80/20 Pareto paradigm. To ensure IT literacy, University of Texas at Arlington officials are requiring students to exhibit computer literacy in five distinct areas in order to graduate from the school. Students must demonstrate proficiency in word processing, spreadsheets, e-mail, the Internet and online research. To meet the standard, students can take a course or pass a computer literacy test.

3.5.3. A Women and Minority Self-Development Program

In order to increase the participation of women and minorities in Information Technology, we must also create an environment to attract minority professors to academia and retain them. Since there are so few minority women faculty, universities must make a commitment to nurture and support them in their competitive efforts. As long as women and minorities continue struggling without guidance and fail to attain the levels of publications and funding required for tenure, many will simply give up and leave academia. When women and minorities leave, students lose a role model to inspire them. It is clear that academic IT, and computing in general, demand more than the ordinary dedication to keep up with technology changes. It has to be admitted that without a support structure one could only do but so much. I think there needs to be *particular* encouragement for minority women to attend short courses, research groups, seminars, etc. that help promote and speed up their professional development after their doctoral work. We could create a self-development program with the purpose of enhancing one's career that would help minorities in general, and particularly women, to cope with the pressures of the profession. Professional women are pulled even more than men and in many various ways away from the academic IT arena.

> *"My own sense from more than 30 years of experience in Higher Ed is that it is a very male and WASP oriented environment, particularly in administration… how does one find out the most effective approaches to diversify Higher Education - and other educational environments - throughout the nation, particularly in IT and SMET topics?"* —Oscar Garcia

3.5.4. Vocational Tests Could Supplement HS Counseling

The quality of career counseling in high school varies from fair and excellent to non-existent, depending upon the school system, public or private. Sometimes instruments like the Junior Engineering Technological Society (JETS) exam and the Strong Career Interest Inventory, which help students identify their abilities, fill the gap left by of poor counseling. It forces the student to ask questions - which at times a counselor cannot answer - such as "Who is an Information Technologist? A Computer Scientist? A Computer Engineer?" and other questions relating aptitude in math and science and other career correlates. Some of these tests also pick

> *"The quality of career counseling in high school varies from fair to excellent to non-existent depending upon the school system."* —Giorgio McBeath

the students' top interests and identify the dominant ones. This methodology should be implemented in all schools to assist counselors/students in selecting career fields, especially where IT demand exists. The ACT career survey indicated in 1999 only 4% of all high school students taking the exam considered computer science and related fields as a potential major. Yet, the demand is estimated to be 118% for programmers, database administrators, network technicians/engineers through 2006. We should not leave to random selection career choices without input from knowledgeable adults and at least some psychometric data. How many students carry the question in their minds "What is an Information Technologist (IT)?"

3.5.5. Technology, Race, and Income

On July 6 of last year a panel titled "Technology, Race, and Income" met in Washington, D.C., with CSPAN coverage, to discuss problems related to low income earning urban populations and their knowledge and access to technology. In particular, the high predisposition to use computers at home generated by acquaintance with computers at school and at work was cited. There was a significant gap in underrepresented minority use of technology at work and at school which indicated that this lack of access to IT would be transferred to the home also, thereby reducing automatically the future equalization of economic and educational opportunities for children of those minorities. This clearly perpetuates the underrepresentation. Also there was a proposal for a "technology opportunity tax credit," a refundable credit for the purchase of computers for educational home use. A conclusion of the meeting was that there was more than just a problem with Internet access but also that the overall information access in telecommunications was a victim of the digital divide.

3.5.6. Inheriting ethnicity is not the same for all

One question, particularly evident in the Native American population, is that of who belongs to a given ethnic group after the first generation if parents are of different ethnic background themselves. For Native Americans, the test of belonging to this ethnic group seems rather restrictive: 1) after intermarriages beyond a grandchild there is no more Native American heritage in the population, and 2) if membership is not kept in selected organizations, Native American heritage is not accepted. This leads to the likelihood of a shrinking Native American population and a smaller proportion of participation in IT or whatever other activity we choose to consider. In the U.S. the surname is lost for children of Hispanic females but it is not clear to me whether the claim can be made when there is ancestry and whether it is up to the individual to make the claim. For Blacks and Asians, it is not a matter of surname but of physical characteristics. Clearly, Native Americans are treated differently than other groups. Whatever the rule may be, it should be the same for all ethnicities as a matter of fairness.

> *"Hypothetically, if Jim Thorpe's (our greatest American Athlete and 100% native american) son (50%) did not return twice a year to the Pow Wows back at the reservation-extreme bias excludes him from indian population using computers. Beyond Jim Thorpe's great grand child (25%) all native american descendents are excluded. No extreme eliminators are similarly applied to american blacks nor Hispanics…"* —Larry Tippens

3.5.7. The Strategy of the AIHEC

The American Indian Higher Education Consortium (AIHEC) has formulated a High Performance Computing Initiative (HPCI) to bring the developments of the National Computational Science Alliance (NCSA) to the Indian Country with the following goals:

- Bringing high performance computing resources to each campus
- Building a Native American Grid (national infrastructure) to connect those resources together
- Building a distributed Native American technical support infrastructure
- Building a distributed Native American library system
- Building Information Technology workforces in the communities served by AIHEC member institutions

"Access Nodes" allow real time collaborative conferencing over the Internet. This would facilitate the sharing of expert human resources between the campuses.

Bringing leading-edge technology to the tribal colleges and establishing Native American resources will not eliminate poverty or close the Digital Divide (the gap between technology "haves and have-nots") in Indian country unless the economies of reservations are built up. It is this larger picture within which the HPCI resides. How can technology be brought to reservations through the tribal colleges and kept there? This can occur through the development of a skilled Information Technology workforce through AIHEC member institutions designing and implementing Information Technology curricula. These skilled workforces can then be kept on-reservation by inviting industrial partners to participate in the development of these curricula and then hiring graduates remotely.

Clearly, the dual and complex major needs are of infrastructure and human resources. But there is a strong socioeconomic component to it also.

3.5.8. Career Counseling and Surveys

> *"More research should be done on how young people choose their careers, the people who influenced them, or what event or events or information played a key role in their selection. I also don't believe young people have a very broad comprehension of what careers are out there and what is involved in preparing for the career and where it could lead them…"* —Nadine Scala

The quality of career counseling in high school varies widely depending upon the school system, public or private. Career counseling instruments like the Junior Engineering Technological Society (JETS) exam and the Strong Career Interest Inventory can supplement favorably whatever other counseling may exist. It is important for young people to find out what careers may exist in this changing horizon of opportunities and their aptitude in those areas relevant to the subject. For engineering, mathematics and science, aptitude may be confirmed statistically by JETS and correlated career interests. If implemented in all schools to assist counselors/students, especially IT where demand exists, such instruments could help students in selecting career fields with some degree of anticipation of success. The

1999 ACT career survey indicated only 4% of all high school students taking the 1999 exam checked computer science and related fields as a potential major. Yet, the demand is estimated to be 118% for programmers, database administrators, network technicians/engineers through 2006.

3.5.9. Vision and Definition of IT: What is an Information Technologist?

The term IT is starting to be used by companies in their recruitment advertisements. The question of what IT is must be answered clearly if we are to attract underrepresented minorities and others to it. The NSBE Bridge, fall 1999 issue defines an Information Technologist as a person who develops and manages information systems that support a business or organization. "IT" embodies the hardware, software algorithms, databases, tactics, and man-machine interfaces used to create, capture, organize, modify, store, protect, access, and distribute information for ultimate use by people. Does this tell enough to a HS student to choose one way or the other?

While the mystery of computers may still attract some people, there is a lot behind the screen that is not so easy to acquire, much less create. Peter Freeman of Georgia Tech referring to IT at a Snowbird conference called it "Computer Science Lite" possibly in the sense of a less rigorous discipline. However, in "The Supply of Information Technology Workers in the United States," published by the Computer Research Association (see

http://www.cra.org/reports/wits/cra.wits.html), it took in Chapter 2 nineteen pages to explain what is IT and the IT worker. The term IT is great because it is generic and covers a multitude of sins. But, by the same token it is also not well defined because it is so broad. We could agree that it should be restricted to computer-based activities, and not to other information media (radio, TV, etc.) activities. Going beyond text processing, spreadsheets, web page making, and PC-based databases, Peter Denning identified (quoted in the same publication) twenty academic disciplines that could constitute professional bases for IT: Computer Science, Information Science, Information Systems, Management Information Systems, Software Architecture, Software Engineering, Network Engineering, Knowledge Engineering, Database Engineering, System Security and Privacy, Performance Analysis (Capacity Planning), Scientific Computing, Computational Science, Artificial Intelligence, Graphics, Human-Computer Interaction, Web Service Design, Multimedia Design, System Administration, and Digital Library Science. Broad enough for you? How can we explain this to a neophyte in twenty words or less? One good differentiation given in the study is that between an IT-enabled worker and IT-worker on the basis of their business and industrial knowledge versus their IT knowledge. The elucidation of this blurred terminology is unlikely to happen soon.

> *"…the most cost-effective action the field could take would be to provide curriculum materials that would show students what IT is like by providing example problems for them to explore and solve."* —James Coggins

In seeking employment graduates are facing the fact that being IT-enabled or computer literate has evolved from being a 'plus', to being a 'requirement', and will become an 'assumption'. Society is likely to evolve to embrace information technology and make it part of our daily lives, including

> *"Should a new IT degree be created? If so, what are the subjects and emphasis areas of this new degree?"* —Carolina Cruz-Neira

CS, CEG, MIS and other less well defined degrees. The problem with a new different IT degree is that the subjects will not be fundamentally different from what is taught in those three classical undergraduate disciplines. It has elements from a variety of disciplines and it may be that a multi disciplinary approach is the way to organize the field. Our effort here is making sure that IT reaches and is attractive to all social groups and races. As IT sinks into our society, current curricula will have to incorporate it into all programs. The same way that an engineer is taught math so he can work with domain-specific formulas, people will have to be taught how to use computers and the increasingly sophisticated domain-specific applications programs and the increased capacity of communication networks. However, our schools should never be permitted to serve short-term objectives by becoming employment agencies or worst. Nonetheless, there are increasing pressures to go to distance education and "just in time" training as required by industrial needs.

Perhaps a single technological vision and definition of IT would not suffice, but many perspectives and views would be required to explain and define IT. In particular, the underrepresentation problems have different aspects within IT spanning from socioeconomic issues to lack of access and human resources. Interlinked minority web sites for sharing common information and furthering mutual understanding of collective and individual problems. A single vision and approach to a definition of IT would require a broad perspective of its development and underlying causes. Some related references are:

- "Information Anxiety" by Richard Saul Wurman,
- "Economic Value of Information" by David B. Lawrence,
- "Globalization of Multinational Enterprise Activity and Economic Development" by Neil Hood and Stephen Young (editors),
- "The Third Wave" by Alvin Toffler would be another good one.

4. Moderators Discussions and Interim Report on Recommendations

After the completion of the second Phase and the summarization of the 52 issues listed in the five topics of the previous section of this report titled "Summary of the Issues Resulting from the Cyberconference Postings," a selected group of moderators exchanged their views in a teleconference. During the teleconference the moderator group decided to group the 52 issues into an overarching group of eleven issues, listed below under "Issues from Teleconference." This was done in preparation to an interim presentation to be made on December 9, 1999 by a small group of moderators to officers of different cognizant programs of the NSF. This summary of the interim report at that meeting is particularly important because it coalesced the issues into thirteen potential research topics, following the 204 documented postings from the Cyberconference. Those thirteen topics are discussed below under the very important section labeled "Potential Research Topics."

4.1. Minutes from Meeting in Room 730 at NSF on Dec. 9, 1999, 1-5 PM

Participants:

- Evans Craig. via conference call, Supercomputer Center at UNM
- Willie Pearson, Wake Forest University, Dept. of Sociology
- Bonnie Sheahan, NSF SBE
- Ruta Sevo, NSF EHR
- Roscoe Giles, Boston University / EOT-PACI
- Caroline Wardle, NSF CISE
- Andrew Bernat, UTEP, Dept. of Computer Science
- Oscar Garcia, PI Wright State University
- Rita Rodriguez, NSF EPSCOR Program

Dr. Wardle had a brief introduction that reminded us that the objective of the Cyberconference was to elicit research questions, not necessarily methods of implementation of presumed solutions.

4.2. Statistics of postings (presented by Dr. Garcia)

Phase I took place over 4 weeks and Phase II lasted 3 weeks. There were five topic areas and postings on the first one, as usual, were more frequent. There were 136 registrants (vs. 230 in women's virtual conference) of which only 29% posted a total of 204 messages; those posting averaged ~5 postings/participant but there were less than 1 message per registrant so that many people didn't post (similar to women's conference). The distribution was:

Topic Cluster	Postings in Phase I	Postings in Phase II	Total posting per topic	Total number of issues raised	% of posting in this topic
Outreach	48	26	74	15	36%
Teaching K-PhD	36	8	44	9	22%
Research	18	5	23	6	11%
Mentoring	31	11	42	13	21%
Other	10	11	21	9	10%
TOTALS	143	61	204	52	100%

Dr. Wardle reminded the group again that her charge is to write up a research program that will address the underlying reasons for the underrepresentation of women and minorities in the IT workforce. The afternoon was a total immersion in issues that was useful and necessary.

An electronic report of the meeting was needed in the short term and these rough minutes were part of it. The final report is expected early during the following year. Dr. Wardle interacts with a cross-disciplinary NSF group representing constituencies who would be interested in research efforts to develop an initial program with a focus on certain key areas to be determined.

Dr. Garcia strongly suggested the need for a long-term plan up-front because short-term efforts are unlikely to solve the workforce and minority problems, which unfortunately is at variance with typical NSF policy in setting up programs. Dr. Wardle states that there is need to answer the first 12 research questions to know the form of #13 (reference is made to "Potential Research Topics"). Dr. Garcia indicates that given timetables and rate of change, when all answers are obtained for the first twelve they will be obsolete and not meaningful for the last one.

Dr. Giles points out that we know the causes why minorities do not participate (historical discrimination); he suggests that we rewrite questions as targeted to our audience, thus impacting explicitly the targeted populations.

Dr. Rodriguez agrees that we need a meta-plan to make sure effort goes forward.

Dr. Pearson suggests that we target document towards policies at NSF; GPRA requires short-term focus even though long term is necessary.

Dr. Rodriguez indicates that the economic issues of IT are so significant to the country that this is a unique opportunity to drive minorities forward and contribute to solving a national human resource problem.

Dr. Craig agrees that we need sustainability; need inter-agency collaborations as well; same issues keep coming up in study after study.

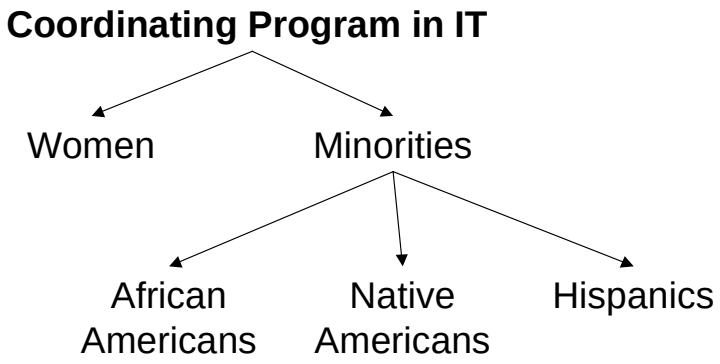
Dr. Garcia declares the meeting adjourned on time (5 PM).

4.3. Issues From Teleconference

4.3.1. Aggregation vs. separation

Separate programs are needed to approach various communities since communities are very different (their present status in relation to IT, how can they be engaged) but some problems are common to all. Symptoms are similar, but at times causes and solutions may be quite

different. Social issues and groups working together are important. Issues are what granularity of disaggregation? Gender disaggregation? Geographic differences matter (even within the same ethnic group). Differences between fields of SMET; issues of sciences vs. IT matter. Much of this has been brought up over the years, but not followed up on. For instance, the Native American Telecommunications Forum brought up 67 issues and 35 strategies (see http://www.ahpcc.unm.edu/Alliance/Tribal/ITREPORT/sld001.htm for cross-referencing) and they keep being rediscovered; findings, summarization, interpretation and dissemination of relevant portions of studies already done is needed. Pieces of the problem are actually shared also by the culture of the majorities and research needs to be done there as well; but do we wish to argue for it? Many of the issues are general population issues with accentuation for minorities and women. Top-level coordination is essential. Must balance between separate small programs at the leaves of a tree and one coordinating structure at the top:



4.3.2. Coordinating efforts

Tremendous amount of data/reports/activities are available with invaluable information from government agencies (NSF/SRS, NTIA, etc) and private foundations and scientific societies; how do we use, filter, interpret, and disseminate them? Agencies may not be coordinating. Reports need to be made cohesive; summaries are needed because of massive amounts of data; effective ways of using them for action. Very time consuming to accomplish the study and summarization. Reports must be relevant to the audiences in order to achieve results. Is it possible to build an information system that makes it possible to combine this information in an easy manner for interpretation? This could be a very concrete project - building the information basis for examining the issue of minority participation - involving data mining with interpretation. We must be careful that analyzing reports does not substitute for actual programs. Timeliness of assessment is very important in this rapidly changing field.

4.3.3. Specificity

Alluded to in the first item above; what is an appropriate level of specificity on geography and corresponding granularity on ethnicity and their problems? Example: 3-dimensional map of US with minority populations by ethnicity as vertical axis; compare that to a similar map with Internet node access as vertical axis.

4.3.4. Research vs. assessment vs. implementation

There are results being obtained in programs that bring minorities into IT but they are not uniformly evaluated. We need to understand the magnitude of the problem of attracting

minorities to IT. We need to understand what has been done and what the results are, what works and what does not. We do not want to start from a *tabula rasa* every time. There are questions at all levels - research, appropriate assessment strategies, appropriate implementation strategies. Many of the participants in the Cyberconference presented issues which were more focused on implementation and showed little patience with doing more research on questions that had been already studied. But there are research questions in all areas - theoretical research frameworks, research into what are the best assessment strategies are, and research questions about what are the best implementation strategies to actuate a particular theoretical framework. There are real questions about the willingness of some people to make real data available due to the fear that it will be used against them if they are not 100% successful. We need to know what works and, under what conditions does it work? Assessment ideally provides feedback but it is seldom used; we have the continuous loop research - implementation - assessment. This is formative evaluation for program improvement rather than pure summative evaluation. It is important to separate issues of quantity from questions of quality in minority program assessment - how do we measure this? Is critical mass of minorities with IT knowledge more important than fewer shining stars? These are hard questions to answer. It seems better to use the term "shining stars" rather than call it "quality" because the latter is a relative term. Previous studies indicate that critical mass is important. What constitutes critical mass and whether it is indispensable is another example where relevant information is not accessible to IT work: studies need to inform any new work to leverage on past efforts. These questions hold for the issue of quantity vs. quality in women in IT and for other issues also. Similarly, many women in IT become involved in women's issues early in their careers and do not build their careers first; this seems to hurt their progress later in their academic careers. Do you invest your resources in bringing a few people way up or many people partway up? What is the proper mix/balance?

4.3.5. Research on how to best develop human resources in IT

Even simple back-of-the-envelope computations (as pointed out in the Cyberconference) indicate that we cannot fulfill projected needs of IT workers. What is it going to take to move up the ladder in education? What would put it on the table? Bringing together (unbiased!) working groups could provide unbiased accounting of reports and program assessment. Coverage of topics and views reported by different groups is very uneven. Human resource development does not have sufficient cachet in our environments and cannot be truly accomplished by instantaneous or short-term projects. For the foreseeable future we will under-produce IT workers even with wildly successful programs. From the Native American point of view there are very few resources being put in to IT workforce development. There is an infrastructure problem that hinders workforce development. There is a second front in the human resource front - it is in the major research institutions where minority students need to succeed to show that it can be done. What can make human resource development of recognized value at these institutions so that interest in developing minority students in IT helps faculty rather than hurts their careers at these institutions?

4.3.6. Mentoring

Much has been studied and written on mentoring but more dissemination of proven summarized results (assessment, manuals, handbooks) would not hurt. Mentoring can be harmful if not done correctly by instilling under expectations. How do we get our arms around mentoring in a productive and practical way? Mentoring works if done right and done in the

right environment. But there are still many questions left open about mentoring: Can it be done on the web? Best one on one? Cross ethnicity? Cross gender? Is it very different if done face to face? We should not confuse role models (no interaction, observed at a distance) with mentoring (direct interaction). There are research questions on distance vs. interaction. Mentoring can happen at majority institutions as well as in minority serving institutions. There is a problem for mentors who spend too much time early in their careers mentoring and later don't make progress. This may result in greater harm done to the community than good (by resulting in the loss of good examples). Also, as mentioned, poor mentoring can do harm in different ways. A mentor must hold minority/women mentees to high standards just as for majority students, else the mentor would be setting them up for failure. Possible research topics could include the intersection of IT and mentoring (web, etc.), that is, can IT technology itself help IT human resource development? Can one teach effective mentoring? There are specific studies on mentoring available but can these results be generalized? IT will have a global impact so anything that we learn in relation to minorities will have global impact to other areas and is a worthy investment. "Internet time" is much faster than real time and may impact many on how mentoring happens. Mentoring has always happened in a natural way - "good mentors" know what is relevant. Nobel laureates tend to have been students of Nobel laureates. It is not negative in that sense. There is also peer mentoring, not just student mentoring, to be researched. There is a reportedly high tenure-denial rate for minority faculty, perhaps because they have so many opportunities and demands due to their status. Mentoring must be targeted to specific groups - someone who can mentor one group might not effectively mentor another. Mentoring needs to be valued by social and academic standards. Bad experiences make a major impact on minority and women students if they are not sure that they should be participating in the first place; males may be more aggressive/secure in their perceptions and may not have such negative impacts. We must learn whether mentoring can be taught and training provided. There are differing styles of mentoring based upon the medium of exchange - face to face, vs. by phone, vs. by web. However, it is difficult to overcome existing social stereotypes.

4.3.7. Minorities at majority institutions

It is a fact, for example, that ½ of the African-American college population enrolls at majority institutions. Some research questions are: to what extent is this true for those with IT interests? What about other minority populations? We cannot afford to not deal with ½ the population of interest but seldom we recognize or assess the magnitude of the human potential in "Predominantly White Institutions" for minorities. Is there a reward structure for faculty at those institutions? Frequently even public expression of support does not turn into practical support in these cases. Can we find out if it is possible to build a (possibly virtually connected) critical mass of minority students at majority institutions? There must be incentives for faculty at majority institutions to become involved - real incentives. Could prototyping distance learning activities at majority institutions have a real focus on serving students at other institutions that cannot afford to offer certain advanced courses? Many institutions serving mostly majority students but with significant minority populations may have the resources to create IT access, servers, courses, etc. oriented to use by themselves and by minority institutions. Can they create and maintain resources that are eventually taken over by minority institutions? These must be true partnerships, not charity. NSF has encouraged in the past the re-emphasis of education integrated with research. Could one determine the effect of award programs that integrate

research and education for faculty and for those institutions that value this integration? Can we truly measure progress in this integration in IT so that we may reward institutions for it?

4.3.8. Career counseling

A common perception is that present performance of High School career counselors is very poor mostly because of their low knowledge level about IT. The counseling office is a good location for understanding what students want to know and what career counselors need to know to do a better job. It is believed that there are significant problems because personal bias or preconceived limitations towards women and minorities by career counselors. Career counseling presents serious issues of fairness and has great potential for negative impact if not done correctly and with expert knowledge. Updating career counselors could have a multiplying effect on students with IT potential being correctly channeled to their proper major. Can such perceptions be studied, quantified and corrected? Can objective, possibly computerized, aptitude testing lead capable students towards IT such as the JETS program does for engineering? How can IT aptitude be assessed? What is aptitude in IT anyway and what are the basics that could promote it? Many students drop out very early in their school careers: when is it optimum to test them for accurate counseling? Even if we can test them, can we say what makes someone a good programmer? It may not take the same aptitude to make a good computer scientist or computer engineer (compare, for example, the historically evolved aptitudes for glass blowing and for chemistry). Which is a better approach: to test if the student has abilities that are used in information technology or to test the student's interest in IT based upon a series of questions? IT is a very dynamic and varied career - there are lots of differences from one type of IT position to another IT position - how do you test meaningfully for such a wide range of aptitudes? An advantage of well-controlled automatic testing is that it is impersonal and uniform and perhaps can get away from the individual bias of counselors. This would be particularly true if research were to show that it could be done on the web and generalized. Research on testing in this manner wouldn't have bias if done correctly and it would be IT helping to improve IT. For some ethnic groups such as Native Americans on the reservations and others in inner cities, such testing would present specific problems because the students may have a virtual lack of IT knowledge or frame of reference in their worlds. But everyone does manipulate information even if they aren't using technology to do it and could possibly (?) develop talent in information manipulation and transformation. Can we take advantage of this in the test developed? What does it take to motivate able students to take the first step into an IT career if they don't have something pushing them in - parents, church, counselors, teachers, etc.? Then having taken the first step, subsequent steps may be easier. In general, for minority students, knowledgeable counselors and teachers have a very serious impact since many minority parents do not have college in their backgrounds. Can this be quantified?

4.3.9. Training vs. education

> *"I would love to be MCSE Certified (Microsoft Certified Service Engineer) it cost $7000 at Phoenix University and if you know of monies I could apply for I would appreciate your assistance…"*
> —Wanda Smith

The current burst of new businesses in the IT industry is a two-edge sword: one edge - very appealing because there are good jobs available - the flip side is that minimal knowledge is enough to get going even without significant educational content. BDPA

gives instruction in Visual Basic and encourages Microsoft Certification and moves right into e-commerce vs. providing a bigger picture of the state of the art. A difficult research question is: How can we make training a pathway to education, rather than a never-ending sequence of learning new releases? Industry makes very similar demands - wanting universities to take up costs of training so that their bottom line is not affected, but often not making their commitment to the student/employee long-term educational growth. There are needs to provide "education in IT" which go beyond just fulfilling the immediate IT workforce needs. However, training and employment provide a topical and financial startup for students as they continue their education - "much better to learn Visual Basic than burger flipping" as someone said. For example, colleges and universities train students to be system administrators because they can't hire professionals; students learn a great skill and the most ambitious and motivated continue their education. To accomplish the longer term educational task requires industrial participation and collaboration. What is the ethical obligation of industry toward their employees? Can practices be studied? Cooperative education programs may help in this regard. Does meeting IT workforce demands require education or just training? The key difference is that IT changes continuously - without education, obsolescence comes quickly. There are serious issues involving the training provided in two-year community and junior colleges. Society encourages "just-in-time" education - just enough taken quickly enough to do the job. There is a significant difference between an IT professional and a skilled IT worker. There is a characteristic of IT that relates to chaos theory: small changes in the marketplace produce major differences in other seemingly unrelated areas. The Western Governors University is trying not to create a new curriculum but to make one out of existing courses.

4.3.10. SMET results do not necessarily transfer to IT

We can see differences when we try to involve students in research and compare how it is done in two fields such as physics and computer science. Introductory Physics students do not necessarily have any deeper understanding of the tools they're using than CS students do, but they have the excitement of being a full participant earlier in the learning experience while CS students climb the ladder of knowledge very gradually. Are there IT tools that can be used as motivational forces that provide interactive participation in the learning experience? Perhaps we need an "IT Circus" like we have physics circuses. How can we make IT sufficiently evolved and refined to produce useful and motivational educational tools? Computational Science may provide possible bridge to the chasm. The SMET and the IT people do not need to know everything about each other's field. Similar questions appeared in the early evolution of science and engineering.

4.3.11. IT is "the" prototypical multi-disciplinary changing discipline

How can the breadth of IT be made evident to minorities to attract them to the field? IT moves into science, goes across management, is used in art, and encompasses most areas of human interest. It is a key enabling technology for many fields. There is a serious problem explaining what IT is in terms that are understandable, meaningful or relevant to students (or teachers-counselors) since a clear image or vision of IT, uniformly accepted, is lacking. Like a collage of activities, IT is hard to explain. It seems that confusion about IT may be long lasting - for example computer science is not about the science of computers; topology is similarly difficult to explain. Perhaps a nice "IT circus" would help by conveying the concepts of information and technology in a very visual fashion. We don't want to focus just on technology

as it changes rapidly and ignores the intellectual content of information. We can portray IT as an empowerment for automation, communications, as a vehicle for creativity, customization, etc. In the past we reduced information content in order to make things feasible (limited options on cars, clothes that don't fit exactly) - what will happen in the future as we can handle larger and larger information content? Faculty members are often not the best to speak to students about technology and IT changes, as they are frequently not at the forefront of it.

4.4. Potential Research Topics

Each topic below is intended to be most applicable to underrepresented populations (although they may be also meaningful for the majority population at large, in the same manner that help for the disabled also helps the able) and the items in parenthesis refer to the list in the "Summary of Inputs" for the two Phases of the Cyberconference.

4.4.1. The important issues of access (see inputs 1.2, 1.3, 1.4, 1.5, 1.9, 2.1, 2.2, 2.3)

Lack of equal access, different priorities are needed for different groups, much work done on SMET issues not quite relevant to IT, parental involvement is needed, CBTs are starting to appear in some cities (Chicago, EDUCAUSE). Research: What are the differences in connectivity for different groups of underrepresented populations? How can we quantify and catalog the problems of access in differing ethnic communities? What are the most appropriate methods to provide access to specific communities? Access is key to learning and using IT resources. Access includes methods of interaction with technology, distance learning availability, differing interfaces, connectivity to similar ethnic or social groups geographically dispersed, etc.

4.4.2. Vision and definition of IT (see inputs 1.6, 1.7, 1.8, 5.9)

Research is needed to find a natural common thread in the collage that makes up IT. Such would allow training to be followed by education. We also need to understand what might make IT of specific interest to underrepresented populations beyond just securing a job. A vision of IT would help in giving it a professional career image. For example: how hardware relates to software, and how databases relate to networking, with all other theoretical and application areas in between.

4.4.3. Reports, databases, too much information that goes uninterpreted (see inputs 1.10, 1.11, 1.12, 3.6)

There is an enormous number of reports, initiatives, activities, etc. that are rediscovering in different ways different aspects of the issues of underrepresentation. There is need for research on how to build a clearinghouse and perhaps an IT workforce workbench that synthesizes information and data. Government and foundation efforts need coordination and common assessment methods that are comparable and allow sensible interpretation. We are inundated with data and do not understand the full causes of the problem. We need to relate syndromes to knowledge possibly through data mining and interpretation.

4.4.4. How to make training lead to education (inputs 1.13, 1.14)

Minorities very susceptible to training when new technologies are developed as it leads to quick employment/income, while sacrificing the present for the future personal and professional

development. Research on how to make a seamless transition (or as seamless as possible) so that there is a continuum between beginning vocational training and building up to an education. Need industrial collaboration in this research effort.

4.4.5. Understanding factors of IT career selection, improving aptitude identification and counseling related to minority populations (see inputs 1.15, 5.2, 5.4, 5.8, and some in Teaching K-PhD)

Research on counseling methods and effectiveness, what should a counselor know about IT, how to rate the IT "aptitude"? Related to the vision of what IT is and how it appeals or not to minorities. How to make the IT possibilities known to K-12 students everywhere? What is involved in teaching an IT curriculum? How to best teach the teachers and keep them current?

4.4.6. How to execute, recognize and reward quality teaching in IT (see inputs 2.4, 2.5, 2.6, 3.4)

Research on faculty recognition, positive and negative factors. Are present attempts to recognize and assess teaching of minorities effective? Evaluation of cost of teaching IT and how to ameliorate the drain on school resources. Research on modeling the "pipeline" and identification of "leakage points."

4.4.7. Distance learning development in IT, when and where and how does it work? (see inputs 2.7, 2.8, 2.9)

Research on assessment of distance learning and need for relevancy, as required for interest in the reservations at least and possibly elsewhere.

4.4.8. US citizens rather work in IT than go to IT graduate schools, foreign IT students turn into workers as a safety valve for industry, who will lead in IT in the US? (see inputs 3.1, 3.2, 3.3, 3.5)

Research on what are long term consequences? Research at Universities in IT (for example networking) is very difficult to conduct because industrial demand makes graduate teaching and study not economically competitive. Research on how to model, quantify and assess the seriousness of the manpower problem, particularly at the advanced degree level. Research on social, economic, and educational factors that act as barriers for IT graduate study by underrepresented minorities.

4.4.9. The BIG issue of mentoring (see inputs 4.1 through 4.13)

We know a lot, but what can we do with it if we were to codify what we know? What are the effective and most practical ways of mentoring? Research on consolidation of what we know and can prove, evaluation methods, categorization of mentoring, and scale-up. Issues of data validity, distance mentoring, novel approaches, cross ethnicity/gender, etc. Research on common problems with mentoring of women and minorities.

4.4.10. Different issues for different ethnic groups in different locations (and vs. women's issues)

Need interpretation, not just analysis (see inputs 5.1, 5.5, 5.7). It is not possible to sweep all different ethnic issues under the same rubric as geography and sub-ethnic groups also vary the

possible approaches. Need to research numbers and develop a realistic strategy to cope with the problem.

4.4.11. Can self development and life-long learning be taught and used effectively? What kinds of materials are most cost effective? (see item 5.3)

Research on IT methods for life long learning. Research on what "every IT professional should know" and "how will an IT professional keep up with change." Methodologies for continuing education and delivery essential for IT's pace of change.

4.4.12. Understanding what is needed in research vs. assessment vs. implementation (see teleconference topic 4 above)

The natural tendency of minorities is to identify problems and provide solutions. Many programs have been carried out. There is need for research on how to integrate the continuum of research already done or to be done with proper standardized assessment methods with implementations whose success or lack thereof informs further research. Isolated pieces do not help.

4.4.13. What programs and how would one assure or sustain effectively the continuity of programs over long periods of time (an overarching issue).

The general problems of education (K-PhD) and participation of underrepresented minorities are exacerbated in IT because of its accessibility and technology demands, its rapid change, and its pervasiveness. It is clear that short-term isolated agency efforts in using "silver bullets," while well intentioned and brave, cannot cope with the enormity of the multidimensional problem. A long term, sustainable effort, with interagency, professional and scientific society, and private foundation coordination is needed. Three to five year efforts could not be sufficient, as it is necessary to impact a wide segment of the US population. Flexible planning, regularly evaluated over a long period of time (a decade as a minimum), require also integration of information over a long period. Sustainability requires political and social will. There is a window of opportunity that should be open in using IT itself as a mechanism for true democratization.

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6. Appendix II

Research Foundations on Successful Participation of Underrepresented Minorities in Information Technology: A Virtual Conference

Project Summary

This project is oriented to finding research directions for the determination and remediation of fundamental causes that prevent underrepresented minorities (Blacks, Hispanics and Native Americans) from participating in the mainstream educational and research opportunities in Information Technology.

The project will be carried out with minimal travel, and will utilize NSF software support for a virtual environment. The co-coordinators, the moderators, and the discussants will interact via the WWW by posting and summarizing ideas, concepts, and opinions on four topics that we will cover (outreach, teaching, research, and mentoring) plus any other items not covered in those areas. The names of the four topics are only labels that we have chosen and incorporate broader issues as described later.

The "Cyberconference" will produce a report to inform the community of the results of the exchange and will be appropriately disseminated.

6.1. Purpose of this proposal

The purpose of this proposal is to disclose the fundamental research issues underpinning the success factors for the participation of underrepresented minorities [OMB] in careers at all levels in Information Technology (and particularly, in Computing Science and Engineering.) A number of attempts have been carried out, with varying degrees of success, to bring underrepresented minorities (Blacks, Hispanics, and Native Americans) to participate in the mainstream of the information sciences and technologies. The research hypothesis is that no systematic body of data or theory currently exists to guide the actions to be taken toward this goal. The anecdotal and common sense approaches that have been taken with varying degrees of success will also be considered in the discussion, but the emphasis will be on the research necessary to firmly determine the root causes of the problem. The research topics, to be described in a final report, should contain innovative and promising ideas to aid in formulating a research agenda on the topic of minorities in computing.

6.2. Motivation for this proposal

Changes are sweeping our computer-intertwined real lives in many different directions and our society is being further fragmented, not only by levels of education, financial status, and ethnic background, but also by accessibility to and knowledge of what Herbert Simon called "the world of the artificial." Just as with many other educational-related issues, but this time more pervasively, the world of interactions with computers has extended from programming to dialogs

and navigation in virtual and simulated worlds of information, in a manner that will further divide our children and adults into "haves and have-nots." The underrepresented minority population in the United States, while increasing in numbers, is decreasing in people entering the computer field, at a time when the bounty of new opportunities seems to be rising without end in sight. Large segments of the population, on the basis of gender and ethnicity, are not participating in proportional numbers in supplying the information technology needs of the nation. Why? What can be done about it?

A number of answers, some based on very realistic reasoning, have been provided. But no organized scientific research approach has been taken to ascertain fundamental causes to inform a methodology of action.

This proposal does not advocate any specific methodology of action, but an open forum where constituencies may exchange ideas and inform each other of the areas to investigate so that such methodology of action be soundly understood. We are proposing to investigate what should be the research agenda that may provide solid foundations to ethnological solutions. The magnitude and complexity of the problem are so great that it is not expected that we will find a "silver bullet" to solve the problem. But we hope to determine the most promising lines of research that will lead to a comprehensive and integrated approach over a spectrum of educational environments ranging from K-PhD. In the information society of the new millennium, the typical worker is rewarded with good benefits and salaries if he/she is "IT-enabled" or else he/she may not be capable of holding any other than the fewer and fewer unskilled positions available. At the same time, the Technology Office of the Department of Commerce [DOC] has identified a significant workforce deficit. Projections provided by the Bureau of Labor Statistics indicate more than one million new IT workers will be needed between 1994 and 2005 as computer scientists and engineers, systems analysts, and computer programmers [BLS]. For the same period, an annual average of 95,000 new workers will be needed. Given that our current national production (in 1995) was of 22,367 US citizens and permanent residents with Bachelor degrees in Computer Science, 6,452 at the MS level and 617 at the PhD level, we see that we have a severe shortage of human capital. The Information Technology Association of America has reported large and increasing shortages of IT workers [ITAA].

A recent report published by the Computing Research Association of a committee lead by Peter Freeman and William Aspray under an NSF grant [CRA], with support of the "Intersociety Working Group on Information Technology Workers," also reported on the shortage of minorities in Information Technology. Table 7-3 (page 114) in that report shows the small percentile of doctoral degrees awarded by ethnicity. The reports also points out that underrepresented minorities in Computer or Information Science as a group, once in college, graduate at a higher percentage rate than non-Hispanic White males. We suspect that this is not true throughout all ethnic groups. Also, we must remember that the number of underrepresented minorities entering Colleges or Universities is very small. The report states:

Many of the reasons that discourage women from IT careers also apply to minorities. There are very few minority role models in information technology. Minority students are less likely to have computers at home or at school on which to gain an early exposure to information technology. Students who attend historically black colleges and universities face limited computing facilities, compared with the average U.S. college or university. But there are other reasons as well. For example, minority students who want to devote their lives to helping their

communities do not regard information technology as a social-conscience field. Students with that goal are much more likely to train for careers in law, medicine, or politics.

An NSF study [NSF99] by ethnicity of the US population and Computer Science production indicates a significant imbalance (numbers for 1995 but representative in general) between the composition of the population and the percentile production of computer scientists:

- The White, non-Hispanic population accounts for 73.5% of the US population and contributes 69.44% of BS, 65.17% of MS, and 73.42% of PhD degrees in CS.
- The Asian ethnic population accounts for 3.40% of the US population and contributes 10.57% of BS, 19.20% of MS, and 22.37% of PhD degrees in CS, well above its expected ratio of representation.
- The Black, non-Hispanic population constitutes 12.00% of the US population, and contributes 11.17% of BS, 5.38% of MS, and 1.78% of PhD degrees in CS, showing a remarkable decline in the expected ratio at graduate degrees.
- The Hispanic population constitutes 10.40% of the US population and contributes 5.84% of BS, 3.07% of MS, and 0.97% of PhD degrees in CS, a very low index of representation at all levels of the educational spectrum.
- The American Indian and Alaskan Native population constitute 0.7% of the US population and contribute 0.49% of BS, 0.25% of MS, and 0.00% of PhD degrees in CS, an extremely low level of representation at all levels, particularly in graduate degrees. We are also interested in including the Native Pacific Islanders to whom little attention has been given in this ethnic category.
- Graduates of unknown ethnicity account for 2.48% of BS, 6.93% of MS, and 1.46% of PhD degree productivity in CS.

The conclusion is that, at the time when the country is in great need of expertise in the Information Technology field, computer scientists considered minorities (with the exception of Asians, constituting 23.1% of the population) are contributing in disproportionately low ratios to satisfying that need. They are also not benefiting from the information revolution taking place in the mainstream of the US academic, government, and business environment.

This concern is certainly reflected in the strategic goal of the National Science Foundation as outlined in the Government Performance and Results Act Strategic Plan FY 1997B2003 in its intent to "strive for a diverse, globally oriented workforce of scientists and engineers."

6.3. Some previous and ongoing efforts

This is not a previously unrecognized problem, albeit one that has been difficult to tackle because, among other obvious reasons, of its technical complexity, its social sensitivities, and historically long ignored educational deficiencies.

Without attempting to be encyclopedic we will try to cover some well-recognized efforts, which may offer background information for this study. Participants in this study will be invited to contribute to establishing a resource of literature and electronic reference material relevant to Information Technology and the ethnic deficits and its potential related research for solutions.

However, while it may be important to bring the pertinent previously considered issues up for discussion again, we hope that some innovative and "out of the box" thinking in a scientifically well founded manner, with a good sociological informed basis, takes place.

The National Science Foundation biennially conducts congressionally mandated studies on "Women, Minorities, and Persons with Disabilities in Science and Engineering." These studies report on the status of women and minorities in science and engineering. The reports document both short and long-term trends in the participation of women, minorities, and persons with disabilities in science and engineering education and employment. The ninth of these reports with the most recent data was published in May 1999 [NSF99]. Some of the highlights from this report, related to minorities in Science, Mathematics, Engineering, and Technology (SMET), are given below with only minor format changes. We would expect that most, if not all, would be applicable to Information Technology, but notice the underlined parenthetical remark about the field of science entered by underrepresented minorities and their employment.

1. Although substantial differences in course taking by racial/ethnic groups remain, the percentages of Black, Hispanic, and American Indian students taking many basic and advanced mathematics courses doubled between 1982 and 1994. For example, in 1982, 22 percent of Black high school graduates had taken algebra II. By 1994, 44 percent had taken this course.

2. Racial/ethnic groups differ greatly in mathematics course taking. Black and Hispanic high school graduates in 1994 were far more likely than White and Asian students to have taken remedial mathematics courses. Thirty-one percent of Black, 24 percent of Hispanic, and 35 percent of American Indian high school graduates, compared with about 15 percent of Whites and Asians had taken remedial mathematics in high school.

3. Significant differences in mathematics and science achievement by race/ethnicity remain. Average mathematics scores increased for all racial/ethnic groups since 1990, but differences between White students and Black and Hispanic students have not significantly decreased. For example, among 12th graders in 1990, the average difference between White students' mathematics scores and those of Black students was 33 points. In 1996, it was 31 points. (The National Assessment of Educational Progress measures mathematics achievement on a scale ranging from 0 to 500.) The average difference between White students' mathematics scores and those of Hispanic students was 25 points in 1990; in 1996, it was 24 points. (Note: we have some interesting evidence from the Houston area. The state mathematics test for elementary grades, when broken down by ethnicity, show that for grades 1 through 5 performances for all ethnic groups' passing rate are about the same. But they go downward from there on for Blacks and Hispanics, while they remain about the same for the White non-Hispanics and Asian groups.)

4. College enrollment and degree attainment by minorities have been increasing. Although minority enrollment in undergraduate programs dropped in the early 1980s, it has been steadily increasing since 1984, both in numbers and as a percentage of total undergraduate enrollment. In 1984, underrepresented minorities were 14.6 percent of all undergraduate students; by 1994, they were 20.6 percent. Minority women account for more of the increases in enrollment than do minority men. More than half (59 percent) of

minority undergraduate students are women, whereas less than half (44 percent) of White, non-Hispanic undergraduate students are women.

5. Of the 325,135 U.S. citizen and permanent resident students enrolled in graduate science and engineering programs in 1995 (both full-time and part-time), 14 percent were minorities. Blacks (6 percent), American Indians (0.5 percent), and Hispanics (4 percent) continued to be underrepresented relative to their proportion in the population. Field choices of minority women in science and engineering are more similar to those of White women than they are to those of minority men. Higher proportions of women than men within each racial/ethnic group are in computer or mathematical sciences, life sciences, and social sciences and lower proportions are in engineering Asian women differ from women in other racial/ethnic groups in that relatively small proportions of them are in social sciences.

6. With the exception of Asians, minorities constitute a small proportion of scientists and engineers in the United States. Asians were 10 percent of scientists and engineers in the United States in 1995, although they were 3 percent of the U.S. population. Blacks, Hispanics, and American Indians as a group were 6 percent of the total science and engineering labor force in 1995 and 23 percent of the U.S. population. (The science and engineering field in which Blacks, Hispanics, and American Indians earn their degrees influences their participation in the science and engineering labor force. Blacks, Hispanics, and American Indians are disproportionately likely to earn bachelors degrees in the social sciences, which are defined by NSF as science degrees, and then employed in social service occupations, e.g., social worker, clinical psychologist, which are defined by NSF as non-science-and-engineering occupations.) Blacks were 3 percent, Hispanics were 3 percent, and American Indians were less than 1 percent of scientists and engineers.

7. In 1995, the unemployment rate of White scientists and engineers was significantly lower than that of other racial/ethnic groups. The unemployment rate for Whites was 2.0 percent, compared with 2.8 percent for Hispanics, 2.4 percent Blacks, and 3.4 percent for Asians. The differences in unemployment rates were evident within specific fields of science and engineering, as well as for science and engineering as a whole.

8. Racial and ethnic groups differ in employment sector, partly because of differences in field. Among employed scientists and engineers in 1995, 51 percent of Black, 57 percent of Hispanic, 64 percent of Asian, and 62 percent of White scientists and engineers were employed in for-profit business or industry. Blacks and American Indians are concentrated in the social sciences, which are less likely to offer employment in business or industry, and are underrepresented in engineering, which is more likely to offer employment in business or industry. Asians, on the other hand, are over represented in engineering, and thus are more likely to be employed by private for-profit employers.

9. Black, Hispanic, and Asian faculty are less likely than White faculty to be full professors or to be tenured. Some, but not all, of the differences in rank and tenure are related to age differences. Black, Hispanic, and Asian scientists and engineers are younger on average than White and American Indian scientists and engineers. When age differences are accounted for, differences in rank and tenure are reduced. For example, among ranked faculty between the ages of 45 and 54, 50 percent of Hispanic faculty, 55 percent of

Asian faculty, and 59 percent of White faculty were full professors. Among Black faculty in that age group, however, 25 percent were full professors.

10. Black science and engineering faculty had, on average, fewer publications since 1990 than did science and engineering faculty in other racial/ethnic groups. Among scientists and engineers who received their doctorates in 1990 or earlier and who work in 4-year colleges or universities, 29 percent of Black faculty had no publications since 1990 compared with 14 percent of Hispanic, 12 percent of White, and 8 percent of Asian faculty.

11. Black and American Indian faculty are also less likely than other groups to have Federal grants or contracts. Thirty-five percent of Black and 25 percent of American Indian doctoral scientists and engineers employed in colleges or universities are supported by Federal contracts or grants compared to 45 percent of all doctoral scientists and engineers employed full time in colleges or universities.

12. Asians are less likely than other groups to be in management or administration (14 percent of Asians compared with roughly 22 percent of Hispanic, White, and Black scientists and engineers). Age differences do not explain this difference in managerial activity. Among 35 to 44 year olds, Asians remain less likely to be in management; 13 percent of Asians and between 20 and 23 percent of other groups are in management or administration.

13. Salaries for scientists and engineers differ little among racial/ethnic groups. Among all scientists and engineers, the median salaries by racial/ethnic group are $50,500 for Whites, $50,000 for Asians, $45,000 for Blacks, $47,000 for Hispanics, and $48,000 for American Indians. Within fields and age categories, median salaries of scientists and engineers by race/ethnicity are not dramatically different and do not follow a consistent pattern.

14. Black and Asian women scientists and engineers are more likely than women from other racial/ethnic groups to be in the labor force and to be employed full time in a field related to their degree. Seventy-one percent of Black and 72 percent of Asian women scientists and engineers compared with 61 percent of White, 68 percent of Hispanic, and 65 percent of American Indian women scientists and engineers were employed full time in their field.

15. Median annual salaries of minority women are more similar to those of both White women and minority men after accounting for field and age. Among engineers in the 20- to 29-year-old age group, for example, the median salary of Hispanic women was $40,000, for Black women $42,000, for Asian women $37,700, and for White women $38,800. Median salaries for men engineers in the same age group ranged from $38,000 to $40,000.

The same study indicates that Blacks, Hispanics, and American Indians are less likely than Whites to participate in higher education whether in science and engineering or in non-science-and-engineering fields. Although Blacks, Hispanics, and American Indians as a group are 23 percent of the U.S. population, they are 21 percent of college enrollment, 14 percent of non-science-and-engineering bachelor degree recipients and 13 percent of science and engineering bachelor degree recipients. These statistics, however, obscure the differences among

the three ethnic groups by grouping them together. We define Indices of Representation as the quotient of the percentile production of BS, MS, and PhD degrees by ethnicity in a given year divided by the percentile of the overall population of a given ethnicity. Given the ethnic population distribution in 1995 (a year for which we have population and productivity data from [NSF99]) shown below, we can compute these indices for Computer Science.

Ethnicity	% 1995 Overall Population	% B.S. Productivity Index of Representation	% M.S. Productivity Index of Representation	% Ph.D. Productivity Index of Representation
White, non-Hispanic	73.50	94.48	88.67	99.89
Asian	3.40	310.99	564.80	657.83
Black, non-Hispanic	12.00	93.07	44.82	14.86
Hispanic	10.40	56.19	29.51	9.35
American Indian	0.07	7.26	35.43	0.00

While Information Technologies involve areas other than Computer Science, it is likely that these statistics are somewhat representative of other computing disciplines. While figures for Blacks receiving Baccalaureate degrees in CS are encouraging, the indices of representation at the graduate level and at all levels for other underrepresented minorities are dismal. By comparison the indices for the Asian ethnic group look extraordinary.

In 1994 a "Workshop on Increasing Participation of Minorities in the Computing Disciplines" was funded by NSF under the award CDA-9401736. The conference took place at the Airlie Center in Airlie, Virginia on May 4-7, 1995. Bryant W. York chaired the conference. The conference was preceded by a set of position papers submitted by the participants. Summaries of those position papers are available in [BYork95]. Five main themes, briefly summarized here, were addressed in those position papers:

1. **Leveling the Playing Field**. The position papers in this category considered the historical barriers that have prevented minority institutions (MIs) from evolving more competitive and broad programs and how these could be overcome. The roles of minority vs. majority institutions were considered, the possible partnerships, Internet participation, models and success stories of MIs, set-aside programs and leveling impact, political equity, and the broad range of existing federal programs trying to solve these problems.
2. **Pipelining**. The pipeline is looked upon as the sequential feed-through of the educational system from Kindergarten to doctoral programs (K-PhD). In particular, the questions addressed relate to what are the social, cultural, and educational factors that may be brought to bear to stop the "leakage" of human capital in the underrepresented minority pipeline. The roles of mathematics and the computing culture to stimulate students in K-12 are also considered. The importance and scarcity of role models for minorities are addressed in these position papers, as well as the effectiveness of the NSF programs in existence at the time.
3. **Institutional Environments**. The purpose of these papers is to determine the types of institutional environments that are most conducive to the production of underrepresented minority graduates. Three major aspects considered were: a) the physical/electronic infrastructure, b) the human infrastructure, and c) the social context. Distance learning,

access to computing resources, use of high-performance machines, etc. were among the physical infrastructure topics. On the human infrastructure the main topics dealt with sufficiency of faculty at small institutions to provide quality Computer Science/Computer Engineering educational and research experience, the idea of "collaboratories" and REUs, the production of graduates at all levels in sufficient numbers, and the market for underrepresented minorities in computing. On the social aspects the questions of minority friendly vs. minority hostile institutions and nurturing perceptions were addressed, as well as the profile that industry is seeking in underrepresented minority graduates.

4. **Quality, Evaluation, and Measurement**. As MIs adventure into advanced degree programs the question of maintaining quality and measuring and evaluating it is raised. How is this measurement/evaluation to be done and by whom? How are the general perception and reality aligned? How can quality be improved when such is needed? What is the role of non-minority institutions in these efforts? How can projects be designed to demonstrate the value and/or difficulty in enhancing the quality of graduate programs?

5. **Mentoring and Starting in IT**. There is little question on the value of mentoring, but it is a labor intensive and specialized activity. The questions raised are: What are the qualities of a mentor at the different levels (undergraduates, graduates, other faculty)? Must the mentor also be a minority ethnically related? Is there a role for peer mentoring? Must the mentor and mentee be co-located? Can mentoring be done at a distance? What are the doctoral advisor responsibilities before and after graduation? What is the role of professional organizations in mentoring?

A report on the conference was issued in 1996 [BYork96]. We quote from the report:

"The most significant conclusions to come out of the workshop are the following:

- *A variety of types of mentoring is essential to the success of students at all levels. The base of mentors must be expanded. Same gender and same ethnicity are not required. Scalability of mentoring is a problem.*
- *The reward structure of academic institutions must be revised to reflect the importance of teaching and mentoring.*
- *The nation needs explicit metrics for evaluating teaching and mentoring.*
- *Despite the current glut of PhDs in computer science, some minority institutions should develop PhD programs in computer science.*
- *The computer science community needs to acknowledge the continuum of need from basic computer information literacy to PhD-level research.*
- *All academic institutions (minority and majority) need to clearly articulate their missions. Different missions have different infrastructure requirements.*
- *The notion of replication of successful federal programs needs to be more carefully analyzed.*

- *Better coordination between professional organizations, community organizations, industrial organizations and educational institutions with respect to the overall development of children is possible through effective use of the Internet.*
- *New K-12 curriculum in information management which is integrated with traditional mathematics and science is required."*

In other efforts, the NSF Partnerships for Advanced Computational Infrastructure program (PACI) which supports two awards, the National Partnership for Advanced Computational Infrastructure (NPACI, PI Sid Karin, University of California San Diego) and the National Computational Science Alliance (NCSA Alliance, PI Larry Smarr, University of Illinois), have also been involved in outreach activities. EOT-PACI is the joint education, outreach, and training activity of these two partnerships and is lead by Richard Tapia, Roscoe Giles, and Greg Moses.

The PACI program is focused on developing and prototyping "the grid" for scientific and engineering applications. The grid is an emerging network infrastructure that links people, high-performance computers, sensors, instruments, and data repositories. It has the potential to be a universal source of computational and information power analogous to the electrical power grid. The technological and human problems of defining, constructing, and refining the grid are daunting but are being addressed across the nation. Grid prototypes involve the use of existing higher than Internet speed networks such as vBNS and Abilene. The grid has the potential to be a force that will empower individuals and groups who have hitherto been marginalized to take a strong role in the new information age. Failure to seize this opportunity can result in a threatening amplification of inequities across our society, and a loss of valuable input into national research initiatives. EOT-PACI is committed to inclusion of underrrepresented groups in the design and exploitation of the grid.

EOT-PACI is working with successful mentoring and outreach projects such as those at Rice and the University of Houston-Downtown to scale to a national level, working with EDUCAUSE to encourage and support effective use of high performance networking at minority serving institutions, partnering with the Coalition to Diversify Computing (CDC) - a joint effort of the CRA, IEEE-CS, ACM, and ADMI - and with the CRA Committee on the Status of Women in Computing (CRAW). Projects and exhibits at conferences are devoted to increasing the number of women and minorities in computing and to attract young people to science and computing. The EOT-PACI projects are evaluated by the Learning through Evaluation, Adaptation, and Dissemination (LEAD) Center at the University of Wisconsin at Madison (www.cae.wisc.edu/~lead). EOT-PACI also participates in the "Coalition to Diversify Computing" or CDC mentioned before (www.npaci.edu/Outreach/CDC/) as an outreach and mentor pairing group. The concept of the CDC was apparently originally conceived at the Airlie conference and taken up by other groups as a joint effort. Dr. Roscoe Giles, who will be co-coordinating this Virtual Workshop with the PI of this proposal, and is very active in PACI-EOT, is Professor in the Department of Electrical, Computer, and System Engineering (ECS) at the College of Engineering of Boston University.

6.4. Constituencies - student participation

We can consider the organization of this workshop as having two coordinators and seventeen moderators. In addition, a much larger number of discussants will take part in each of

the two phases of the workshop. We have moderators that have special experience. For example, Richard Aló indicates that he could interact with parents, teachers, and employers. He and his group at the University of Houston have worked with "Master Teachers" and could get them to participate. Also there is a large group of minority students who could participate from that area. It would be ideal if the workshop could include all four kinds of people involved in the decisions that students of different ethnicities make in choosing a career and an educational process. These are according to function:

- **The parents**: they will be the hardest to get to participate in the exchange. However, there may be participants in the other categories who can play a dual role.
- **The teachers**: they will range from elementary to high school to college/graduate school. They are the ones who deliver the educational content, which enables the success of the students, and have therefore much input to provide.
- **The students themselves**: they are the main subjects of the study and should therefore have their say in why and how their educational decisions are made.
- **The employers**: they are representative of the degree of satisfaction with the education in information technology provided to the students, and with the other factors affecting the making of a good employee.

Even if all four groups are not equally or substantially represented, the identification of a point of view in the electronic exchange ("speaking as a parent," "from the point of view of a teacher," etc.) would be important in evaluating the perspective of the comment.

Should there not be an organized repository in the WWW where each of these constituencies could find information on whom to deal with underrepresented minority issues related to information technology? There are many different groups of people working on different aspects of these issues that do not even know what others are doing in the same or in a closely related area.

During the first phase (first month) the moderators will orient the discussion along four main lines:

- The outreach and high school motivation and preparation factors which influence the choice of careers and preparation of the student for success in a college program in the computer and information technology field. Ken Anderson from Siemmens, Giorgio McBeath involved in WSU's Wright STEPP outreach program, which collaborates with the Dayton (OH) Public Schools, and Evans Craig, Education, Outreach and Training Manager of the Albuquerque Supercomputer Center, will participate as moderators in this group. W e will use the term "Outreach" as an oversimplified handle for this area, with full recognition that we are talking about a variety of caring and motivational factors that are complex, and that it takes a group of people reaching for another group of people to establish a positive experience.
- The educational basis and the educational technologies (computer-based learning technologies) which may aid or hinder in the development of a scientifically and technologically motivated budding information technologist in the K-PhD environment. What are the relationships between the cultural and social environment and the success in school? What is the availability of information about the field of computing - in public

schools with significant minority enrollment for example? What can students learn on their own and what must be taught in the classroom? What is the relationship between public school teacher competence and enthusiasm in the use of computers and students' interest in a career in computing? How does exposure to computers in elementary and secondary schools (feelings of competency and literacy) relate to affinity for computing as a career? How do colleges and universities prepare teachers for diverse populations of students? These are difficult questions that will be moderated by Henry Frierson, Professor of Educational Psychology at the University of North Carolina at Chapel Hill (at the undergraduate and graduate level), Etta Hollins who is Associate Dean of the College of Education at Wright State University, and Richard Aló, Professor and Director of Center for Computational Science and Advanced Distributed Simulation, Department of Computer and Mathematical Sciences at the University of Houston-Downtown. For simplicity we will call this line of discussion "Teaching" although it clearly has a very broad implication in motivation and preparation for a professional and lifelong career that goes beyond teaching.

- The graduate research and education aspects, and the mentoring and guidance that are associated with it, are important components of the virtual conference given the low indices of participation for Computer Scientists of all ethnic backgrounds. The question of the relationship between minority institutions' graduate programs and majority institutions' support of those programs is a delicate one. How should the success, or lack of thereof, be measured and evaluated in minority graduate programs, and by whom? How can the quality of minority institutions' graduate programs or the cooperation with majority institutions be improved? What is the role of non-minority institutions in providing guidance to minority students who feel isolated in their midst? What guidance and post graduation follow-up is necessary/desirable to insure the success of the few minority PhDs? Is there credence to the anecdotal stories that Blacks with doctoral degrees in CS go overwhelmingly into industry instead of into academia because industry has done a better job of making diversity an integral part of their organizational values and salary structure [CRA]? Bryant York, Associate Professor and Research Director College of Computer Science at Northeastern University and a recent recipient of the CRA Nico Habermann award for service to underrepresented groups in the computing disciplines, Mario Gonzalez, Vice Chancellor for Telecommunications and Information Technology, The University of Texas System, Celestine Ntuen, Professor in the Department of Industrial Engineering at North Carolina A&T University, and Ricardo Gutierrez, Assistant Professor of Computer Science and Engineering at Wright State University will cover these topics relating to minorities and their research and graduate programs. Henry Frierson will also participate in this discussion. This area is easier to identify with the label of "Research" but it also involves undergraduate as well as graduate experiences and scientific, mathematical and computing motivation at the high school level.
- Finally, along the dimension of mentoring and sociological success factors at all points along the pipeline, we ask the questions of how to learn, teach, and optimize this labor-intensive art of human motivation and caring. How can faculty be encouraged and taught to be caring, committed, and competent in handling the special problems of underrepresented minorities? How can both minority and majority institutions learn to

reward such efforts? How can we encourage role models without burdening underrepresented minority faculty with a well-intentioned excess of committee and other assignments as frequently happens? What are the possible profiles of mentors and how can we identify systematically the good mentors? What are the training and typical functions and rewards of mentoring? How could technology laboratories, businesses and professional societies encourage the mentoring of underrepresented groups by their industrial, government and academic leaders? How can the role and nurturing of the extended family be enhanced at needed times in the pipeline, and how can distance and isolation hurt and peer affinity groups have a positive influence and be encouraged when needed? These are but a few of the issues to be honed by Willie Pearson, Jr., a Professor specializing in the sociology of science in the Sociology Department of Wake Forest University, by Andrew Bernat, Professor of Computer Science at the University of Texas at El Paso and also winner of the CRA Nico Habermann award for service to underrepresented groups, and Richard Tapia, the first Habermann award winner, recipient of the White House Presidential Award for Excellence in Science, Mathematics, and Engineering and Noah Harding Professor, Department of Computational and Applied Mathematics at Rice University. Because of its special character we call this area of discussion simply "Mentoring" realizing that there is significant overlap with the others. The characterization is that mentoring is more one-on-one (but not only in that modality) than the other discussion topics.

We also hope that a good number of students may participate and many discussants from academia, business, and government will also join us. We will try to seek computing-related student organizations strong in underrepresented minorities to involve their members in some of the virtual interactions. For example, there was an active IEEE Computer Student Chapter at the University of California at Berkeley, of which Prof. C. V. Ramamoorthy was the advisor, which had a strong minority representation.

During the second phase of the interactive exchange, a grouping of participating contributors will take place in which more detailed elaboration on a certain number of group-selected topics will occur.

6.5. What is the same and what is different in our objectives from those of other workshops? Factors.

This workshop is a "virtual" workshop or a "Cyberconference" in the sense that there is no face-to-face meeting, but the communications are carried out over a period of two-months using electronic media provided by NSF. The workshop will consist of two phases. During the first month (October) all participants will communicate with each other and the sorting of issues will be done by the moderators and the two coordinators. For the second month (November) or Phase II of the Cyberconference, the co-coordinators and moderators will reconsider the issues and specify a set of issues similar or different to the initial ones proposed below, according to the inputs.

Rather than imposing a list of issues, this proposal is aimed toward providing an open forum that will allow the participants to identify the issues that need to be researched. There exists a clear and unfortunate correlation between financial status and minorities, a relationship that will have to be taken into account in order to derive valid issues that are specific to ethnicity. It is evident that low family income limits accessibility to computers, reduces the quality of the

education and discourages the pursuit of college and graduate education, all of which are fundamental for careers in Information Technology.

Similarly, there is often a host of problems in the educational background and non-supportive social environment for underrepresented groups. Family income and education are related to the educational preparation and achievement of women and minority pre-college students [NSF99]. For example, there is solid data on how parental income is related to average scores on achievement tests. However, those factors are seldom taken into account in the education process of the student.

Are there any other cultural issues that bias the different ethnical groups toward "traditional" careers? Do ethnical groups experience a cultural resistance to incorporating information technology into their lives? Are these biases common across ethnic groups or are there issues that are specific to each group?

Could we possibly represent the status of potential information technologists as requiring a minimum measure of sufficiency along each one of three axes in the figure involving economic, social, and educational factors that complement each other in a consistently reinforcing way?

It is noticeable in the data given above that the Asian ethnic group has an incredibly high index of representation when compared to either the majority or other underrepresented groups. Could the existence of some of these factors (real or perceived importance of economic, social and educational values) be at play in the high representation of this ethnic group? Could research identify which factors are at play in their success?

6.6. Topics and Timetable for this proposal

The Virtual Workshop format offers the opportunity to solicit input from multiple groups via electronic media. It will solicit inputs from underrepresented minorities in industrial careers, researchers on social issues related to under-representation in IT, students, social scientists, pre-college educators, and others who can contribute either personal experiences or research-based expertise. As such, we will recruit a wide range of participants by announcing the workshop by personal contacts with known contributors and role models, and also through electronic distribution lists and newsletters. The moderators will play a crucial role in attracting discussants. The workshop's goal is to attract a proactive group of participants who can provide information experiences to identify definitive research areas. Attracting participants to the workshop who are representatives of the different constituencies, both ethnically and by role, is one of the main functions of the fourteen consulting moderators.

The intended timetable for this project is:

Month in 1999	**Activity**
August	Refine Goals and Submit Proposal
September	Conduct Pre-conference activities among team members
October	Conduct Phase I of Virtual Conference
November	Conduct Phase II of Virtual Conference
December	Write a Report and get inputs from all participants and team

6.7. Budget for this proposal

There is no equipment in this budget.

Travel is minimal and would be used for reporting, dissemination, and exchanges by the co-coordinators.

The co-coordinators or co-PIs would be paid at a higher level, since their responsibilities are more global than the moderators. The co-coordinators will be involved for the full, five months, duration of the project and will lead the moderators in reviewing the final report of the project. Moderators, in general, will be paid $3,000 as consultants to the project. They will be partially involved in September, but mostly during October and November, in the electronic exchange of Phases I and II, and in the Phase II definition, as well as in reviewing and commenting on the final report in early December. The participants or discussants are not compensated.

6.8. Expected Outcomes

The most important outcome of this workshop will be a report full of original and promising ideas on how to research the fundamental causes of non-participation by underrepresented minorities in information technologies in a broad sense. This report will be disseminated with the purpose of informing the community what this group believes are basic research problems to be solved before programs are put in effect to solve the problem of under-representation. The hypothesis is that the assertion that "we know what the problems are" has not yielded sufficiently significant results when implemented in programs, and that the complexity and magnitude of the issues have not been properly assessed in as a quantitative and definitive manner as it may be possible. Also, we are slowly recognizing that there are delicate issues that are common, and others that are different, when thinking about women and also when thinking about the various minority groups, including both those underrepresented (Black, Hispanic, and Native Americans) and the one over-represented (Asians). The issues have features that are not only educational and scientific and technological in nature, but also sociological and cultural.

We have been warned by people who have been involved in previous studies to avoid at all costs "posturing" by participants. The purpose of the conference is to inform the community of what the research issues should be, not to promote statements of self-righteous indignation among the participants (however valid it might be), but to scientifically and systematically analyze the problem and its interdependent factors to be studied.

This report should be concise but comprehensive, and will be as disseminated as much as possible. It will be published in a professional format in hard copy and in electronic form.

6.9. Brief description of levels of participation in this proposal and suggested participants

We can ideally consider a possible organization of the Virtual Workshop in a matrix structure for Phase I outlined below. While this would be an "internal" organization, during this first phase all coordinators will be involved in all messages/discussions even if they are assigned in different topical groups. This structure will be subject to modifications for Phase II, based on the inputs provided by the participants. The matrix axes will be initially aligned along the four

discussion topics (outreach, teaching, research and mentoring) with consideration of a catchall category titled "Other." The three ethnical groups do not exclude any participants and will very likely have overlap across moderators and coordinators, as shown in the following table, with responsibilities not necessarily related to the ethnicity of the moderators. We also realize that the four designations of Outreach, Teaching, Research, and Mentoring, as explained before, involve serious overlaps and stand for much more semantic content than common use of the words alone would imply.

	Outreach	**Teaching**	**Research**	**Mentoring**	**Other**
African Americans (AA issues) (Coordinators I and II)	AA-O (Moderator)	AA-T (Moderator)	AA-R (Moderator)	AA-M (Moderator)	Anyone
Hispanics (H issues) (Coordinators I and II)	H-O (Moderator)	H-T (Moderator)	H-R (Moderator)	H-M (Moderator)	Anyone
Native Americans (NA issues) (Coordinators I and II)	NA-O (Moderator)	NA-T (Moderator)	NA-R (Moderator)	NA-M (Moderator)	Anyone

We can consider three levels of participation in the workshop:

- **Coordinators**: There will be two co-coordinators with responsibility for all topical areas and with concerns about each underrepresented ethnic group, but willing and able to coordinate and work with people of any ethnicity on common subject matters. The point here is to have particular sensitivity to *special* issues within an ethnic group, but also intensively interested in finding out in exchanges with the moderators about what is common and what is not common in those issues. It should be clear that only by looking for common approaches to research on the issues could the limited resources available be used efficiently, but this should not be done at the price of ignoring that there are differences between the groups. Coordinators will be responsible for (1) proposing the initial discussion topics, (2) evolving these topics, as well as the structure of the Workshop if needed, on a weekly basis, from the inputs provided by the moderators and (3) preparing the final report in collaboration with the moderators.
- **Moderators**: There will be a moderator in charge of each track in the matrix. Moderators do not have to be of the same ethnicity as the group they moderate or issues they comment on. The designation of a moderator for a given ethnicity had more to do with making that moderator, in particular, more sensitive to any comments relating to that ethnic group than with the ethnicity of the moderator. Most important is experience in the four areas and others in dealing with underrepresented minorities. We do not anticipate that the ethnicity of any of the coordinators, moderators, or participants, will be revealed or be an issue in the discussions. Moderators will be mostly responsible for: (1) contacting and attracting relevant participants to the workshop, (2) presenting discussion topics provided by the coordinators and/or suggesting their own topics, (3) ensuring that participants interact in an organized and constructive manner, by editing their comments as needed, (4) submitting weekly reports to the coordinators, and (5) participating as reviewers in shaping the topics for Phase II, and particularly in helping in the editing of the final report.

- **Participants or discussants**: The participants are the fundamental source of input and, as mentioned previously, will ideally represent the four constituencies: academics (researchers, faculty, teachers,), parents, students and employers. Participants will also be encouraged to attract other discussants to the workshop. In order to foster diversity, cross-cultural and cross-disciplinary interactions, all related to the broad field of Information Technology, participants may also be invited to participate in several tracks in Phase II.

Contact information for the coordinators and moderators is shown in Appendix I.

6.10. References and Resources

[BLS] Bureau of Labor Statistics, "1983-95 National Industry-Occupation Employment Matrix Time Series" in "Total Employment 1996 and Projected 2006."

[BYork95] A postscript file "nsfmi_papers.ps" may be retrieved by anonymous ftp. This may be done by accessing, with the ftp UNIX command, the server "ftp.ccs.neu.edu" (without the quotes, of course) and giving the login as "anonymous". Then for the password give your e-mail address. Do a change of directories by the command line "cd pub/people/york" and then the command line "get nsfmi_papers.ps" that will bring in a file to the location that you may specify. Exit with "bye". These working papers together with the final report [BYork96] should give a good picture of the 1995 Airlie Workshop.

[BYork96] "Final Report of the Report on Increasing Participation of Minorities in the Computing Disciplines," Bryant York et al. See: http://www.ccs.neu.edu/home/york/aascc/nsfmi_prop/nsfmi_rep.html.

[CRA] Computer Research Association, "The Supply of Information Technology Workers in the United States," P. Freeman and W. Asprey, 1999.

[DOC] Department of Commerce, "America's New Deficit: The Shortage of Information Technology Workers." See: http://www.ta.doc.gov/reports/itsw/itsw.pdf.

[ITAA] Information Technology Association of America,"ITAA Initiates IT Skills Gap Research Program." See: http://www.itaa.org/news/pr/pr19990412.htm.

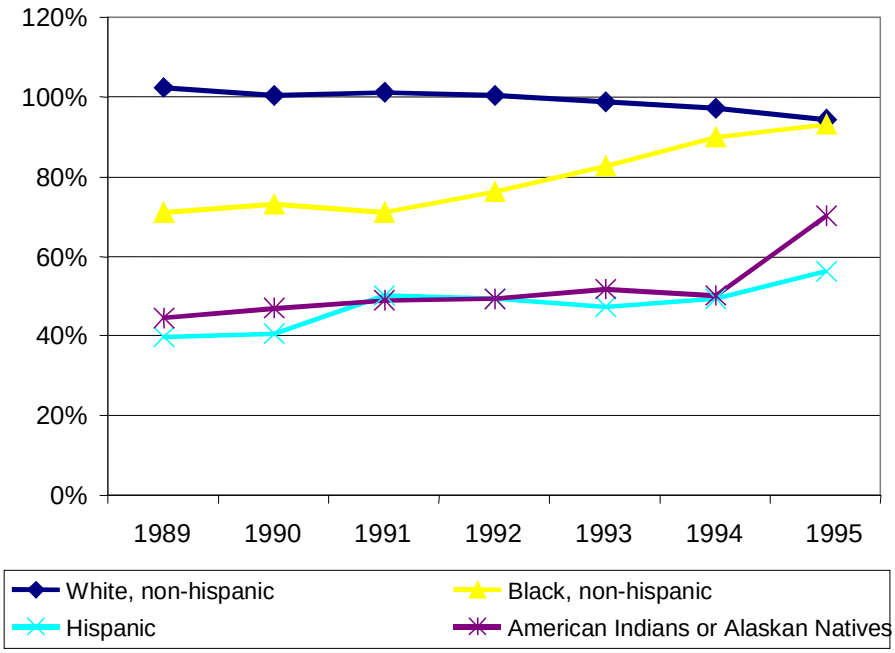
[OMB] In accordance with Office of Management and Budget guidelines, the racial/ethnic groups described in this report will be identified as White, non-Hispanic; Black, non-Hispanic; Hispanic; Asian or Pacific Islander; and American Indian or Alaskan native. In our use these groups will be referred to as White, Black, Hispanic, Asian, and American Indian. The term "minority" includes all groups other than White; "underrepresented minorities" includes three groups whose representation in science and engineering is less than their representation in the population: Blacks, Hispanics, and American Indians.

[NSF99] National Science Foundation, "Women, Minorities, and Persons With Disabilities in Science and Engineering: 1998." Arlington, VA, 1999. (NSF 99-338) See: http://www.nsf.gov/sbe/srs/nsf99338/access/

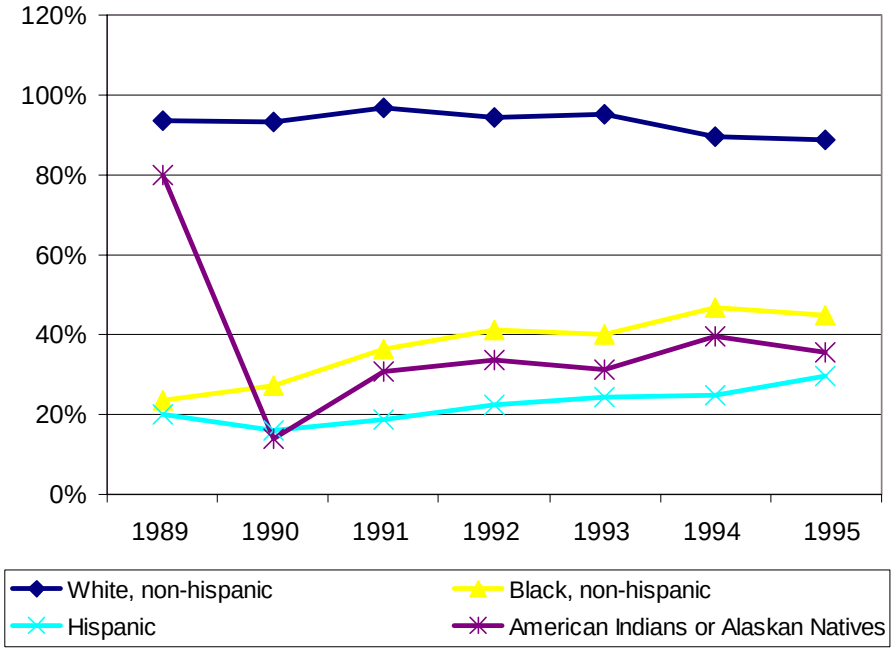
7. Appendix III. Computer Science degrees during 1989-1995

The following plots show the trends in earned Computer Science degrees for underrepresented minorities (US Citizens and Permanent Residents only) during the period 1989-1995 [NSF99]. In order to computer indices of representation, the 1995 race/ethnicity population distribution has been assumed for the previous years 1989-1994.

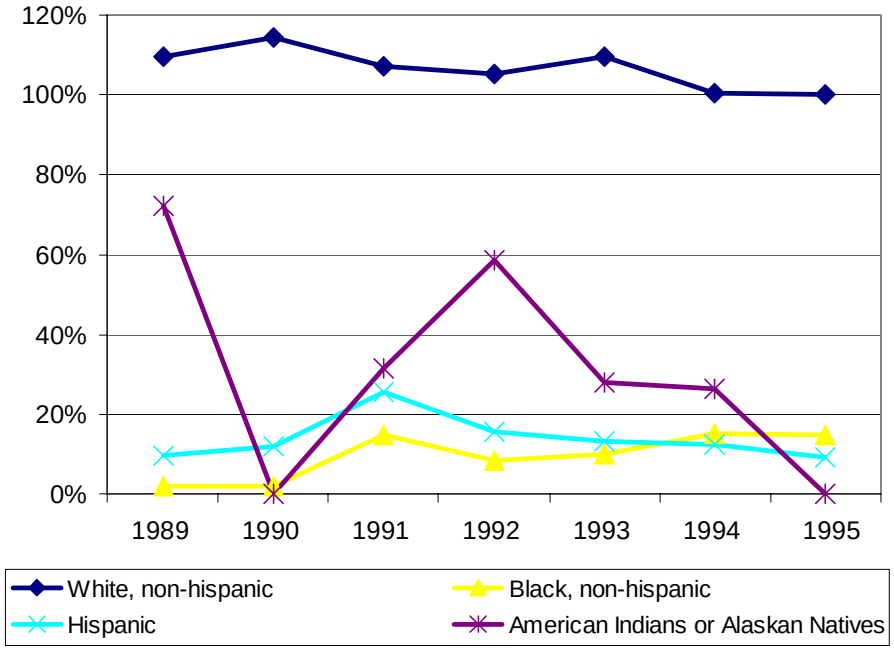
Index of representation. B.S. in Computer Science (w/o Asians)



Index of representation. M.S. in Computer Science (w/o Asians)



Index of representation. Ph.D. in Computer Science (w/o Asians)



8. Appendix IV. Guidelines and Netiquette

Research Foundations on Successful Participation of Underrepresented Minorities in Information Technology: A Cyberconference.

8.1. Workshop Policies

Policies must be strictly followed. Violators of these policies shall lose the opportunity to participate in any further discussion on this site.

1. Privacy must be respected. Postings with potentially libelous content are not allowed and shall be deleted from the database.
2. Postings containing a violation of a law shall not be allowed, and shall be deleted from the database.
3. Postings containing commercial value shall not be allowed and shall be deleted from the database.
4. Postings containing any type of profanity shall be edited or completely removed from the database.
5. Harassment or personal attacks on other participants shall not be tolerated, and shall result in the loss of opportunity to further participate in discussions on this site.

8.2. Workshop Guidelines:

All participants are encouraged to adhere to the following guidelines:

1. Messages should remain brief and to the point. For particularly long messages, post a brief summary, submit the document as an attachment.
2. Format all postings in a manner that enhances its effectiveness. Try to avoid using all capital letters, as this is the virtual equivalent of shouting.
3. Postings should be professional in nature, and must be related to the workshop discussions and goals.
4. When responding by embedding comments, please use the '+' symbol to denote the response.
5. Each posting should make reference to the subject of the message to which it refers.
6. All responses should be directed at the subject, not the person. Strong opinions and criticisms shall NOT be disallowed; however, please make sure that any such postings cannot be construed as an attack on an individual or group.
7. Post URLs and other references in the References section.

9. Appendix V. NSF Dear Colleague Letter on the IT Workforce

Title: Information Technology Workforce -- Dear Colleague Letter

Date: March 21, 2000

National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

Title: Information Technology Workforce

Dear Colleague,

The Federal government plans to increase its investments in fundamental, long-term research in information technologies (IT), encouraging, in particular, research spanning information technology and scientific applications, and in the area of social, ethical and workforce issues. To help ensure that the United States continues its worldwide leadership in IT, we need to strengthen the technological workforce and to produce a continuous supply of well-trained high-quality professionals in engineering and computer and information science (President's Information Technology Advisory Committee Report, http://www.ccic.gov/ac/report/). Without an IT workforce that is large enough to meet both the public and private sectors' growing demand, and that is adept at using and producing information technologies, we surely risk losing the scientific, economic and human resource advantages we now enjoy.

In this respect, the under-representation of women and minorities in the IT workforce is a serious national problem. There is agreement among some of the nation's leading researchers and scientists that systematic research efforts are needed to address this problem. Hence, the National Science Foundation is announcing a new special emphasis on the IT workforce (ITW) that will support a broad set of scientific research studies focussed on the under-representation of women and minorities in the IT workforce.

Research Goals

ITW welcomes proposals that address important research questions related to the under-representation of women and minorities in the IT workforce. While there is no consensus on a single definition of the IT workforce, we encourage researchers to carefully articulate and justify their own definition of the IT workforce model. A suggested, but not exhaustive, list of possible research questions is included in Appendix A. These research topics revolve around three basic themes:

- Environment and Culture: How the environment, culture and other social contexts (e.g., households, neighborhoods, communities) shape interest in IT, and how interest in and use of IT shapes the environment, with particular emphasis on increasing our understanding of developmental issues at different ages.

- IT Educational Continuum: Understanding how the overall educational environment influences students' progress along the educational continuum from grade school to entry into the workforce, and why students who have the potential to succeed in the study of IT disciplines take educational paths that preclude or make it difficult to enter the IT workforce.
- IT Workplace: Why women and minorities who have the potential to succeed in the IT workforce take alternative career paths, what barriers and obstacles they must overcome, and how the IT workplace can foster increased retention and advancement of women and minorities.

Multi-disciplinary collaboration among researchers in IT, the social sciences, and education is strongly encouraged. Research can address issues at the individual level, at the societal level, at the institutional level, or across levels of analysis. All proposals should take into consideration existing relevant research on the IT workforce. Small projects (one to two investigators) as well as medium-sized multi-site team projects (three to five investigators) will be supported.

ITW encourages research using a variety of methods. These include tools design, development and experimental evaluation, simulation and modeling, survey analysis, statistical models, ethnographic work to test models, case studies, and the development of new methods for understanding increasingly complex processes and dynamics of transformation. Formal meta-analysis methodologies across previous studies and intervention programs will be supported in order to build on the results of earlier work and to add to the research base.

ITW will also support the analysis and assessment of existing information tools and technologies and their possible differential uses and implications for Women and Minorities in IT. It will also support the design, development, and assessment of prototypes of new information tools and technologies that will benefit women and minorities in IT.

Eligibility

Proposals may be submitted by any organization eligible for NSF support as reflected in the Grant Proposal Guide (GPG). Multi-disciplinary collaboration between researchers in IT and the social sciences is strongly encouraged.

Proposal Preparation Instructions

Proposals submitted in response to this Dear Colleague Letter should be prepared and submitted in accordance with the general guidelines contained in the Grant Proposal Guide (GPG) NSF 00-02 and must be submitted via Fastlane. Visit our site on the World Wide Web (http://www.fastlane.nsf.gov).

Submission Date

Proposals for the ITW Special Emphasis must be submitted by 5 PM, local time, on June 22, 2000, using NSF's FastLane electronic proposal submission system, see the Grant Proposal Guide (GPG) for instructions. The complete text of the GPG (including electronic forms) is available electronically on the NSF Web site at: http://www.nsf.gov/.

When submitting your proposal, please type "NSF-00-77" in the block entitled "Program Announcement/Solicitation No./Closing Date."

Contact for Additional Information

Please send all inquiries by Email to ITW-prog@nsf.gov.

Award Information

Proposals submitted explicitly in response to this Dear Colleague Letter will be considered for funding as well as proposals that fit the criteria of ITW but which are submitted to other programs, divisions or directorates. ITW awards may be funded for up to 3 years and will generally range from $75,000 to $250,000 per year. Depending on the availability of funding, between 15 and 25 proposals may be selected for support per funding cycle.

Ruzena Bajcsy

Assistant Director, CISE

10. Appendix VI: Research Questions

10.1. Theme 1: Environment and Culture

- Given the relative newness of computing technologies in the world today and the strong demand for skilled IT workers in the US, why are women and minorities underrepresented in various sectors of the IT workforce?
- How does access to computer technology affect interest in IT careers?
- What role does socialization play in the development of individual attitudes, stereotypes, aspirations, educational and career choices related to IT? Do expectations and ethnic values transmitted through family, peers, teachers, and role models influence educational and career choices related to IT?
- How does popular culture through media, toys, games, and the entertainment industry influence educational and career choices related to IT?
- What are the design principles for information tools and technology that encourage and support the interest and participation of women and minorities in IT?
- How do household investments in IT education and equipment for children affect the choices these children make later in life?

10.2. Theme 2: IT Educational Continuum

- Why do students who have the potential to succeed in the study of IT disciplines take educational paths that preclude or make it difficult to enter the IT workforce?
- How does the overall educational environment influence such students' progress along the educational continuum from grade school to entry into the workforce?
- The importance of taking appropriate courses in mathematics and science has long been recognized as an integral part of preparation for IT careers. Why are minorities still under-represented in the study of mathematics and science? What role is played by counselors, teachers, and parents in aptitude identification and encouragement of students to persist in studies necessary for IT?
- IT is increasingly being integrated into K-16 education. What is the impact on women and minorities of efforts to provide access to and general use of computers in K-16 education?
- The traditional focus of entry level computer courses is on programming with extensive work in computer laboratories, and with sequential course prerequisites. What is the impact on women and minorities, of different teaching methods and learning styles in IT education?
- What is the impact of the perception of relevance and social benefit of computing in attracting and retaining women and minorities?
- A variety of information technologies are used in educational settings. What role do they play in attracting and retaining women and minorities in IT?

- Are there common characteristics among women and minorities with advanced degrees in IT that explain their persistence and success in IT fields?
- There are a number of intervention programs in place designed to attract and retain women and minorities in IT disciplines. What are the effects of interventions on the retention and success of women and minorities in IT?
- There are many ways of mentoring students, faculty and workers in the IT fields. What are the effects on the retention and success of women and minorities in IT, of the different mentoring models and strategies? How should issues of replication, scalability and delivery be addressed?
- How can educational institutions be structured and managed to ensure diversity? What is necessary to attract and retain women and minorities as IT faculty? Is there knowledge to be gained from multidisciplinary studies across fields such as engineering, medicine and law, by comparing models of intervention that have been successful in attracting and retaining women and minorities?
- The rapid and continuing changes in the IT work environment fuels the need for IT workers to participate in lifelong education, training and self-development. What is the appropriate balance among these?

10.3. Theme 3: IT Workplace

- Why do women and minorities who have the potential to succeed in the IT workforce take alternative career paths? What barriers and obstacles must be overcome?
- How can the IT workplace foster increased retention and advancement of women and minorities?
- Do quality of life issues related to IT careers such as burnout, long workdays, and lack of social interaction influence retention and career mobility of women and minorities in the IT workforce?
- How do evaluation, reward structures and family-friendly practices impact the retention of workers in the IT workforce?
- Do stereotypes and the status of the IT profession affect the recruitment and retention of women and minorities into IT careers? What are the effects of traditional and non-traditional entry and career paths on retention and career mobility? What are the formal qualifications and desired characteristics of IT workers that are necessary to be successful in IT occupations? How do degrees (or lack thereof) impact career paths and advancement? Do the desired characteristics fit men more so than women, non-minorities more so than minorities?
- Prior empirical work has shown that market as well as environment and culture influence students' and professionals' career choices. What can be learned from investigations of the IT labor markets that might explain the under-representation of women and minorities in IT?

Appendix VII. Limited On-Site Survey

Summary of Comments by W. J. Harris, Media Director, Solarsounds Broadcasting Commercials, Co. and Cyberconference Moderator

Mr. Willie J. Harris, one of our Cyberconference moderators, visited community centers, public high schools, and public and private colleges, including Historically Black Colleges and Universities. Students, teachers, faculty and administrators shared their experience, wisdom, and opinions about the issues connected with attracting and retaining minority students in educational pathways toward careers in information technology.

During these interactions, one particularly noteworthy observation by Mr. Harris was that the high school communities and the college communities consistently differed in their views and experience on the subject of minority participation in IT. In general, the high schools seem to have little activity or even awareness of the relevant issues due probably to a variety of problems such as uninformed teachers and counselors, and budget constraints. For example, virtually no sign of posters, pamphlets, bulletins, etc. was evident in any of the schools to raise interest in or awareness of IT. Students were severely uninformed except when parents were engaged in computer related careers.

However, in colleges, at least within their colleges of engineering and computer science, and in job placement areas, high levels of awareness and interest by students and faculty was evident. Interestingly, however, professors find that very few students switch into IT from other areas, and that mostly they are committed to IT as freshmen.

Public information campaigns regarding IT and related careers are clearly needed. This is particularly desirable at the secondary school level. These should be tailored to each of the ethnic groups and even within ethnic groups from region to region within the U. S. Techniques are available which could prove useful in different circumstances: Live focus groups and professional meetings, print media for bulletin boards at all educational levels, and public service announcements in broadcast media so that the appropriate technique be matched to the intended target audience. There must be particular care to emphasize information about "career" opportunities over just immediate employment with limited education.