Increasing Technical Excellence, Leadership and Commitment of Computing Students through Identity-Based Mentoring

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ABSTRACT

Recent years have seen a growing awareness in the computing education community that initiatives outside the classroom are vital for retaining students and preparing them for a collaborative and dynamic professional environment. Particularly important are programs that develop rich technical skills while increasing students' interest in computing disciplines. We present Computing Identity Mentoring, an intervention designed to increase commitment to computing while enhancing students' technical and leadership skills. This program was implemented at seven universities during 2008-2009. Preliminary results suggest that Computing Identity Mentoring contributes to students' self-efficacy regarding computing and leadership, and solidifies students' commitment to a career in computing. This paper presents early findings on the effectiveness of the approach and illustrates Computing Identity Mentoring in the context of three of the seven institutions where it has been implemented.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: *Computer Science Education*

General Terms

Human Factors

Keywords

Mentoring, project-based initiatives, computing pipeline, diversity, broadening participation

1. INTRODUCTION

Computing students face myriad challenges while moving through their higher education. These students, like those in other disciplines, must adjust to life at a college or university while balancing academic, social, and personal concerns. While computing educators and computing education researchers are actively investigating pedagogical questions that relate directly to students' academic success, there is growing recognition that initiatives beyond the classroom or laboratory may be key to retaining the talented, diverse individuals who will become the technology innovators of tomorrow (*e.g.*, [2, 3, 7]).

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In addition to the challenge of retaining students who go on to graduate with the computing degree they set out to obtain, computing educators have the privilege of preparing students for future employment as computing professionals. Today's computer scientist is regularly placed in interdisciplinary settings where leadership skills such as teamwork and collaborative accountability are of paramount importance. These rich technical skills are recognized as critical components of the computing curriculum by some accreditation organizations (*e.g.*, ABET). In this paper, we present a mentoring program designed to increase retention of students in computing majors while reinforcing and expanding technical and leadership skills.

This paper describes Computing Identity Mentoring, an intervention through which students engage in mentoring relationships designed to increase the students' sense of *computing identity* as defined by a set of cultures, values and practices. Computing Identity Mentoring is an instance of Identity-Based Mentoring [8] with implementation guided by the Thomas Principles for mentoring success (Identity Development, Psychological, Social, and Academic Support, Sense of Belonging, and Leadership Development) [6, 17]. The goals of this program include increasing retention in the major and enhancing technical and leadership skills in computing. The initial implementation of Computing Identity Mentoring has been carried out in the context of the STARS Alliance (Students and Technology in Academics, Research, and Service), a partnership of more than twenty colleges and universities primarily in the southeastern United States. Supported by the National Science Foundation, the STARS Alliance aims to increase the number and diversity of students enrolled in computing disciplines [6].

Based on related educational psychology research, we hypothesize that Computing Identity Mentoring holds benefits for students including:

- Increasing computing knowledge and technical proficiency [7, 12, 16].
- Enhancing skills such as leadership and collaboration.
- Increasing students' commitment to computing majors [4, 5, 9, 15].

Preliminary findings on student perceptions regarding Computing Identity Mentoring at seven U.S. universities support the above hypotheses.

2. RELATED WORK

A variety of mentoring programs exist for computing students, from widespread distributed mentoring models that span across continents, to local peer mentoring programs that meet the needs of an individual department. Computing Identity Mentoring adds an identity-based component to these approaches by basing mentoring activities on a set of Computing Identity Core Values, which we will describe in Section 3.

2.1 Existing Mentoring Programs

Mentoring occurs when a *mentor* serves as a trusted role model, counselor, or teacher for a *mentee*. While mentoring relationships can develop spontaneously in personal or professional settings, Computing Identity Mentoring is an example of an organized program that involves training mentors, formally assigning mentors to mentees, and holding participants accountable for the mentoring activities. This section gives examples of other formal mentoring programs.

The Computing Research Association (CRA) sponsors a number of research-oriented mentoring programs. Among these is the Distributed Mentor Project[1] (DMP) in which female undergraduates spend the summer following their sophomore or junior year working with a faculty research mentor in an area of the student's technical interest. This long-running project has been highly successful in helping participants better understand and feel prepared for graduate school, and to more clearly define their career goals [11]. The CRA DMP is a program for outstanding undergraduates who are able to commit a summer to immersion in a research project, usually in a location other than the student's home city.

MentorNet[2] is an electronic mentoring program that pairs undergraduate and graduate students with professional mentors. These mentor/mentee pairs exchange correspondence electronically in eight-month mentoring relationships. MentorNet provides training, coaching, and support for the interaction. MentorNet mentees regularly report increased confidence in science or engineering and an increased desire to pursue a career in the mentee's field of study [14].

Mentoring programs implemented within academic departments have also shown success with improving student learning and retention. These programs are designed to help students with coursework while smoothing the transition into college or university [10, 13, 16]. Such programs have shown success in measures of diversity, retention, and technical skill enhancement.

2.2 Identity-Based Mentoring and the Thomas Principles

In identity-based mentoring, mentoring relationships form around a group's values, practices, and culture [8]. These cultural considerations can include a student's ethnicity, gender, age, disability status, and field of academic study. In the case of Computing Identity Mentoring, the field of study is the focus of the mentoring relationships, with attention paid to all cultural aspects of the mentees. Thomas' research [17] has identified a set of principles that are significantly related to student's college adjustment and academic success. These principles include 1) Identity Development, 2) Psychological Support, 3) Social Support, 4) Academic Support, 5) Sense of Belonging, and 6) Leadership Development. Computing Identity Mentoring as implemented in the STARS Alliance explicitly addresses these principles in its curriculum. Some of these principles have been considered in previous computer science education research; for example, fostering a sense of belonging has been shown important for students' choice to remain in the major [1]. Computing Identity Mentoring also facilitates open communication about important issues that arise in a mentee's college adjustment [3].

3. COMPUTING IDENTITY MENTORING

This section features an introduction to the Computing Identity Core Values and presents case studies from three of the seven universities that deployed the program during the 2008-2009 academic term. These case studies illustrate how the program was implemented within different institutions' infrastructures.

3.1 Core Values

We define *computing identity* as a sense of pride and belonging to the community of researchers and practitioners in computer science and information technology. In order to build a mentoring program that fosters a sense of computing identity, we utilize a set of core values based on the core values of the STARS Alliance for broadening participation in computing [6]. Table 1 presents these core values and the corresponding four components of computing identity: technical excellence, leadership, civic engagement and service, and community outreach.

3.2 Mentor and Mentee Training

The core computing values described above are implemented within the Computing Identity Mentoring program. Students' year long involvement with the program begins with a training workshop, designed by an ecological-community psychologist, that is intended to engage students in their own identity development. Another important aspect of the training program involves teaching students to learn from each other during a series of targeted exercises. In post-workshop interviews, students who attended the workshop reported substantial benefit from the activities. One important aspect of the training workshop is highlighted by the words of one attendee, "I really liked sharing experiences so that even though we only just met, we already know a lot about each other."

[1] http://www.cra.org/Activities/craw/dmp/index.php

[2] http://mentornet.net/documents/about/programs/one_on_one.aspx

Table 1: Components of Computing Identity

Computing Identity Component	Associated Values
Technical Excellence	Increasing skill and competence in computing [required by all CS curricula]
Leadership	Professional development and teamwork to develop rich professional skills for success in the workforce [ABET/CAC required]
Civic Engagement and Service	Activities that help change the image of computing from a machine-centered to a people-centered discipline
Community Outreach	Efforts to develop students into computing professionals regardless of gender, ethnicity, or disability status

The training workshop includes two developmental phases. In the first phase, Student Adjustment, students discuss what it means to be a computing student. This phase includes modules about college adjustment, personality styles and interaction, and views on diversity in computing. The second phase, Mentoring Skills using the Thomas Principles, includes modules on identity development, psycho-social and academic support, developing a sense of belonging, and leadership skills for mentoring relationships. The training workshop is an important aspect of Computing Identity Mentoring in part because the event serves as a powerful shared experience on which to establish the mentoring relationship.

3.3 Implementation at NC State University

The Department of Computer Science at North Carolina State University implemented Computing Identity Mentoring with graduate students who mentored between one and three undergraduate students each. All mentors and mentees were participants in the broader STARS Alliance. During the 2008-2009 academic year, NC State had four graduate student mentors and ten undergraduate mentees.

Each mentee chose a project that would be the focus of the mentoring relationship throughout the year. The projects were designed to reflect the core values of computing identity and to complement the leadership skills already included in the undergraduate curriculum. As part of Computing Identity Mentoring, each mentee chose from the following types of projects:

- **Research projects** involve conducting undergraduate research, usually in the subject area of the graduate student mentor. Research areas to date have included Artificial Intelligence, Graphics, and Networking. *(Technical Excellence)*
- **Community service** projects involve completing work or performing service for a community organization. For example, one team of mentors and mentees went regularly to a residential retirement facility and rehabilitation center where they conducted technology education sessions with residents. *(Civic Engagement and Service)*
- **Outreach** projects are designed to foster interest in computing discipline among younger students. One such project involved mentoring teams visiting a nearby middle school and conducting educational hands-on activities with computing and robotics. *(Community Outreach, Leadership)*

This project-centered mentoring approach yields a valuable shared experience because the mentor and mentee collaborate on a worthwhile project designed to foster a sense of computing identity. At the end of each semester, all the students gave presentations of their work so that the components of computing identity were visible, in compelling and socially relevant ways, to the other mentoring teams.

3.4 Implementation at USF Polytechnic

The University of South Florida Polytechnic implemented its mentoring through a tiered structure. At the top level was the advisor who oversaw the program. The next level included student facilitators, comprised of past STARS mentors, who supported and led the mentor teams and collected and analyzed logs of the mentoring activities. The mentor and mentee teams were made up of university, community college and collegiate high school students. Together, the mentoring teams and facilitators conducted outreach activities. One outreach activity was a week-long middle school math and technology summer camp designed to build and sustain academic and social excellence. Another outreach activity involved volunteering with the local annual Science Olympics. These projects, conducted by teams of facilitators, mentors, and mentees, create shared experiences that help build students' sense of the computing identity core values.

3.5 Implementation at UNC Charlotte

The Department of Computer Science at the University of North Carolina at Charlotte implemented undergraduate student mentoring through a credit-bearing service-learning course. The course was structured as a repeatable elective seminar for STARS Alliance participants, who selected from a menu of service projects in which to participate. Mentoring was a service project that was combined with K-12 outreach, and had objectives targeted to mentors and mentees. Community building and computing identity were the primary objectives for mentors, who were STARS Alliance participants enrolled in the seminar course. Community building and recruitment into computing disciplines were the primary objectives for mentee participants, who are younger undergraduate students not enrolled in the seminar. During the 2008-2009 year, a total of eight students mentored six undergraduate students. Low performing students who were enrolled in an entry level computer science course were invited to participate as mentees.

Student mentors enrolled in the course chose from one of four outreach service-learning projects to coordinate throughout the semester. Outreach projects consisted of *GameCATS*, using gaming to attract K12 and college students computer science, *High School Outreach* bringing a number of sophisticated computing presentations and hands-on workshops, *COOKIES*, promoting safe computing practices to the community, and *Team Hope*, showing robotics demonstrations to middle school students. The mentors worked with their mentees throughout the term to engage in campus seminars, conduct outreach, and hold monthly in-person meetings. Contact by phone and email were made on a weekly basis to develop the mentoring relationship and discuss the activities. The mentors also participated in additional mentor training seminars throughout the semesters to enhance leadership within the relationship.

The tiered mentoring approach provides benefits to both mentors and mentees. Mentors receive training and are placed in leadership roles within the relationship and the service projects while obtaining academic credit. Mentees receive academic and social support provided within the framework of computing outreach. Both mentors and mentees develop deeper understanding of the computing discipline through their outreach and mentoring activities, in an effort to enhance their commitment to computing majors.

4. DATA COLLECTION AND RESULTS

The 2008-2009 academic year saw the first widespread implementation of Computing Identity Mentoring. In total, seven institutions across the STARS Alliance participated: Auburn University, University of South Florida Polytechnic, University of North Carolina at Charlotte, Georgia Southern University, North Carolina State University, North Carolina A&T State University, and Florida A&M University. The previous section has described Computing Identity Mentoring as implemented in three institutions. A total of 56 students from all seven institutions participated in Computing Identity Mentoring.

4.1 Methods

Student outcomes are measured with a repeated measures pre- and post-survey, quasi-experimental study design with survey responses measured by a six point Likert scale. Students at all STARS Alliance institutions were invited to complete the surveys, but participation was voluntary. The number of respondents who completed the entire post-survey was 111, which constitutes a total response rate of 43% of all STARS Alliance students for 2008-2009. Of these respondents, 30 participated in the Computing Identity Mentoring program, while 54 reported participating in a different mentoring program during the year. The remaining 27 students reported no involvement in any mentoring program. In order to gain insight as to the effectiveness of Computing Identity Mentoring in particular, the results in this section are based on comparing the responses of the 30 Computing Identity Mentoring students ("participants," from this point forward) with the 54 students who had been involved in other mentoring programs ("non-participants," from this point forward).

4.2 Results

Figure 1 displays the differences between participants and non-participants. Students who participated in Computing Identity Mentoring felt, to a significantly stronger degree than non-participants, that they developed their computing skills and knowledge in the past year. The same trend emerged for students' beliefs about their leadership skills. While student knowledge and leadership skills are accumulated as they move through the curriculum, a stronger agreement with these statements on the part of the participants indicates a differential effect of Computing Identity Mentoring.

Participants felt more committed than non-participants to a career in computing and believed more strongly that computing would allow them to get a job they like. The activities involved in Computing Identity Mentoring require a nontrivial time commitment, so it is not surprising that Computing Identity Mentoring participants felt more strongly than their non-participant counterparts that the program had been demanding of their time. On the other hand, participants also felt more strongly (though with weaker statistical significance) that the program had improved their performance in their major, which suggests that the extra time required was not harmful to the students' overall success.

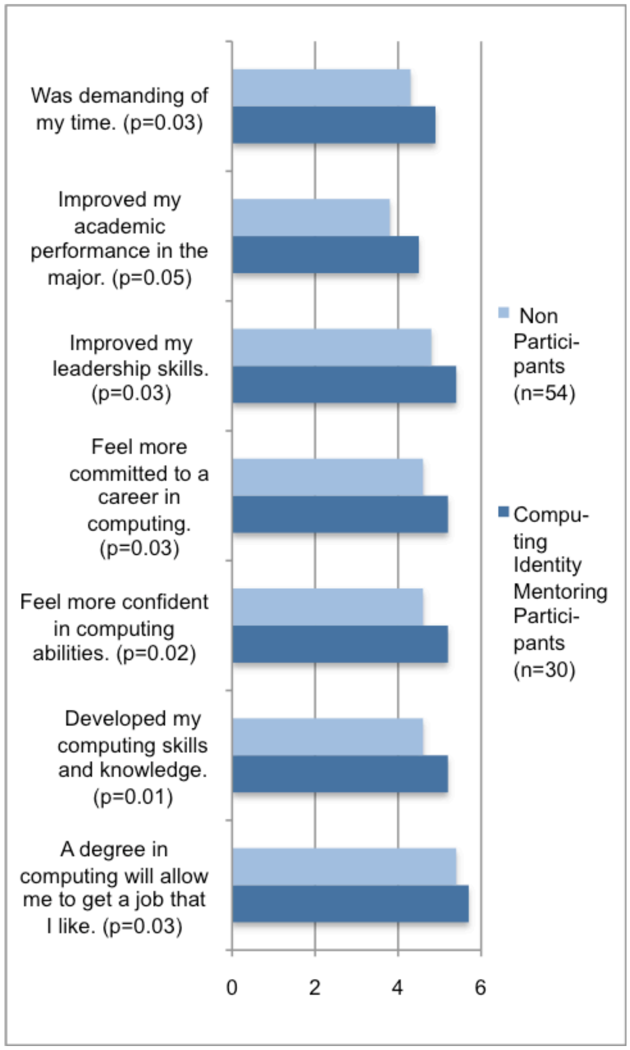

Figure 1. Significant Differences in Post-Program Survey Between Computing Identity Mentoring Participants and Non-Participants. All Respondents were STARS Alliance Participants. (0=lowest agreement; 6=highest agreement; p-values from two-tailed *t*-test)

4.3 Limitations

The findings from the first year of full Computing Identity Mentoring implementation indicate statistical trends that support the hypotheses regarding the effectiveness of the program. Some limitations require caution in generalizing the results. First, the overall response rate to the surveys was low, which means that the students who responded may not be representative of the larger population of students who participated in the STARS program. This issue of representativeness is of additional concern because STARS students, who were selected based on applications to the NSF-funded program, were likely not representative of the overall student populations although the program was open to all students regardless of gender or ethnicity. However, the sampling problem applies to both participant and non-participant groups, so the results clearly indicate a differential effect from participating in the mentoring program.

It is also important to note that the analysis was conducted with item-by-item averages rather than by scale averages; however, future study is expected to provide confirmation of a computing identity scale because of the significance of these initial findings. Additionally, student maturation is a confound for mentor training participants, as most of the participants engaged in mentoring for more than one year. This effect would suggest that computing identity is developmental, which is supportive of the overall hypothesis that computing identity can be facilitated through mentoring.

5. CONCLUSIONS & FUTURE WORK

Computing Identity Mentoring is designed to increase students' sense of *computing identity*. Within the program, this identity is defined by core values pertaining to technical excellence, leadership, civic engagement and service, and community outreach. We have described the implementation of Computing Identity Mentoring in three different academic departments to illustrate the adaptability of this program to a wide variety of institutional structures. When compared to students who participated in other mentoring programs through the STARS Alliance for broadening participation in computing, Computing Identity Mentoring students showed significantly stronger agreement to survey items addressing computing self-efficacy, leadership skills, and commitment to a career in computing. Though these results can only speak to student perception, they indicate that participating in Computing Identity Mentoring positively impacts students in a variety of ways.

Survey data from the first year of widespread implementation indicate that participants of the program feel more strongly than their non-participant counterparts that their technical skills and computing knowledge have increased. The survey results also suggest that Computing Identity Mentoring increases students' confidence in their leadership skills. Finally, mentored students felt, to a significantly stronger degree than non-participants, committed to a career in computing and that a computing field will give them a job they like.

Directions for future work include moving beyond survey responses to collecting data about student performance. Such quantitative data will allow us to more precisely gauge the benefits of Computing Identity Mentoring on student learning, technical skill development, and academic achievement. Retention data for mentoring participants is being collected longitudinally, and will shed light on the retention impacts of the program over time.

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