STEM Strategy: Mentoring Underserved 11th graders in Computer Programming

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Description: *The U. S. needs computer programmers and other STEM professionals. One solution is enticing underserved students into computer science. Research findings support mutual mentoring's positive impact.*
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The overall purpose of this research is to support a National Science Foundation (NSF) funded program designed to provide skills and motivation to underserved high school students for pursuing computer science college degrees. This is a collaborative and comprehensive approach that uses mutual mentoring as one of its components. The more specific purpose of this research is to evaluate if mutual mentoring has an impact on 11th graders as they learn to program computers, a challenging skill to learn, in order to produce a math-based game for first and second graders. In particular, the evaluation assesses whether mentoring changes the mentee's and mentor's valuing of computer science or related fields and whether the mentoring program is perceived as effective. This mentoring program is part of a large NSF funded project.

The objectives of this research are to:

1. Describe mutual mentoring,
2. Present the findings of a mixed method evaluation of the mutual mentoring component, and
3. Discuss implications of research findings.

Perspective/Theoretical Framework

Mutual mentoring differs from traditional mentoring in that the focus is on relationship building and bi-directional influences. These bi-directional influences are expected in skill development and social-emotional impact (Fritzberg & Alemayehu, 2005; Sorcinelli & Yun, 2009). Additionally, the mentee has a network of mentors with whom to interact. In other words, the mentor gains skills and support from the mentee in addition to the mentee obtaining skills and support from the mentor. Moreover, the mentees can change their mentors or get support from a secondary mentor as well as a primary mentor. The most important component of mutual mentoring is the relationship. A strong bond of trust is created within the mentor-mentee pair or network.

Mutual mentoring is especially suited for underserved 11th grade students because mentoring helps with bonding and pursuit of academic achievement. Mutual mentoring also lessens likelihood of dropping out of school, increases self-efficacy, and improves career development (Georgiou, Demetriou, & Stavrindes, 2008; Liang, Spencer, Brogan, & Corral, 2008; and Linnehan, 2001). In order to see if mutual mentoring was effective in this project the mentoring component was evaluated. The evaluation documented that both the mentors and the mentees increased their valuing of computer science and related fields.

Participants & Program Design

There are 10 college-age mentors who are engineering majors. The demographics of the mentors are as follows: 3 females, 7 males, 2 European Americans, 4 African Americans, 2 Latinos, 1 Asian American, and 1 Middle Eastern student who reported his ethnic group as other. The college mentors received training on mutual mentoring and their duties and expectations. This type of training has been shown to be a very important part of mutual mentoring programs (Forsbach-Rothman, 2007). Specifically, the mentoring training consisted of defining traditional mentoring, defining mutual mentoring, differentiating between traditional and mutual mentoring, learning details about mutual mentoring, brainstorming mutual mentoring strategies, reviewing and analyzing Case Studies, completing Role Play sessions, and previewing the specifics of the current mentoring program. Program specifics included their duties, inappropriate behavior from which to refrain, rules of interacting with the students, types of activities in which to engage, and frequency of mentor-mentee meetings.

Then the 40 mentees were introduced to the 10 mentors the summer before the mentees entered their junior year. Demographics of the mentees are as follows: 53.8% are female; 43.6% are Latino (with other ethnicities such as European American, African American, and Asian American); 46.2% speak English as a second language; 76.9% are the first in their family to go to college. All of the mentees attended the same high school that had a 89% participation rate in the free and reduced-priced lunch program. The first interaction between mentors and mentees occurred during a 6-week summer class when the mentees were learning to program. The 10 college mentors visited the 11th grade mentees on Wednesday and Friday during the lab portions of the summer class. The mentees and mentors, along with other program staff, also spent a day together being mentored by local professionals in the computer industry. The industry professionals shared their educational and career paths. They also shared how their current position helps society and any struggles they may have encountered. At the end of the 6-week summer period the mentees and mentors participated in an event where they completed activities to help them get to know each other better and practice team-building. These activities included introductory ice-breakers, a scientific ingenuity contest, and sharing a meal. The mentees' families were also invited to the event. The mentees' families and the mentors also had a chance to view the initial computer games created by the mentees.

During the 6-week summer period the mentors and mentees were initially put into designated groups based on mutual behaviors, characteristics, interests, needs, and requests. However, because of program logistics, the program was not able to sustain these groups. This change was seen as legitimate, because one of the pillars of mutual mentoring is being able to access a network of mentors.

Upon returning to high school for their junior year, the mentees continued to improve their computer programming skills. The mentors visited every three weeks in Fall semester and every two weeks in Spring semester. Not every mentee nor mentor attended every event and/or class session, but a network of mentors was always available at these visits. The high school students were being mentored while learning to program computers. Also at the request of the high school computer teacher, the mentors spent some time tutoring and assisting with homework assignments. During this entire year (Summer, Fall, and Spring), the students used Dr. Racket, Greenfoot, and Java to program computers.

Research Design

A mixed method evaluation of the mentoring program was conducted with a survey that was administered 8 times during the mentor visits to the mentees in Fall and Spring semester. There were 4 administrations of the same survey in Fall semester and 4 in Spring semester, each administration occurred on a monthly basis. Since this was a mixed-method evaluation, both qualitative and quantitative data were collected and analyzed. Relevant open-ended questions were reviewed in order to determine themes. A more formal content analysis was conducted to validate themes. This content analysis had two researchers validating the themes of the open-ended responses. Inter-rater agreement was achieved at 75%. Descriptive statistics were calculated on relevant closed-ended questions. Close-ended questions were likert scale questions or forced-choice response questions.

Results

In terms of quantitative data, 93.8 % of mentors and 62.9% of mentees stated that the mentoring had changed their valuing of computer science and related fields. In all cases, change was an increase in valuing and interest. Additionally, 86.2% of the mentors noticed an increase in their mentee's valuing of computer science during interactions. Both the mentors and mentees rated the mentoring program as effective, with respective means of 3.19 (SD=.74) and 3.23 (SD=.77) on a scale of 1 to 4.

The qualitative data was analyzed by content analysis (Giannantonio, 2010 & Krippendorff, 2004) and themes emerged as validated. The responses of the mentors were analyzed separately from the responses of the mentees. Please remember and note that there are 10 mentors and 40 mentees. Both the mentor and mentee surveys were administered eight times. The first author of this paper and two researchers discussed possible themes that might emerge from the data based on the mutual mentoring theory. Before the data was analyzed, a list of 18 possible themes was generated. This list included the following possible themes;

1. Building relationships;
2. Building trust;
3. Mutual mentoring;
4. Building and utilizing a network of mentors;
5. Getting or giving advice;
6. Increasing knowledge;
7. Increasing skills;
8. Getting or giving emotional or social support;
9. Increased liking of academics;
10. Increased liking of computer science and related STEM disciplines;
11. Increased self-knowledge;
12. Increased self-liking and self-concept;
13. Benefitting the community;
14. Getting or giving respect;
15. Increased agency;

16. Other additional themes;
17. None; and
18. Need more help.

The two researchers who generated this list, excluding the first author, then analyzed 10 mentor surveys with the goal of 75% agreement. At first, 73% agreement was obtained. Therefore, another conversation ensued with the first author and the themes were further defined. Another 10 mentor surveys were analyzed by the two researchers, resulting in 76% agreement. After reaching the threshold for inter-rater agreement, the researchers analyzed the remainder of the mentor surveys. The two researchers then analyzed 10 mentee surveys. In the first attempt, the researchers reached 75% agreement. Subsequently, the researchers analyzed the remainder of the mentee surveys. The top three choices of theme responses for mentors were increased liking of computer science/STEM disciplines, building relationships, and increasing skills. The top three choices of theme responses for mentees were increasing skills, increased liking of computer science/STEM disciplines, and getting/giving advice.

After completing these analyses, the two researchers met and discussed "clustering" the 18 themes based on mutual mentoring theory. The cluster themes were as follows;

1. Individual development (themes 6, 11, & 12);
2. Academic achievement and/or interest (themes 7, 9, 10, 13, 15);
3. Inter-personal skills (themes 1, 2, 3, 4, 5, 8, & 14); and
4. Miscellaneous (themes 16, 17, & 18).

The clustered themes were then ranked by number of responses. For mentors, academic achievement and/or interest ranked highest. The second ranked cluster was miscellaneous, with student mentors needing more help or creating additional themes. The third cluster was inter-personal skills and the fourth was individual development. For the mentees, ranking was similar. However, for mentees academic achievement and/or interest ranked highest. The second ranked cluster was miscellaneous, with the 11th grade students needing more help or creating additional themes. The next ranked cluster was individual development and the last was Inter-personal skills. For the cluster rankings, theme 17 (the response of none) was not included.

Some comments from the mentors and mentees illustrate the top theme clusters. For example, the college mentors and 11th grade mentees made statements such as, "I really do want to learn more about this field." The students also said, "I am learning how to locate a file + compile it." "I have seen the value of computer science field early," is another statement made by the students. These statements refer to the top-ranked academic achievement/interest cluster. The second ranked theme cluster was really marked by mentors and mentees wanting more time together. The college mentors and 11th grade mentees made statements such as, "Need time to spend with students." There were also statements to this effect, "There isn't more bonding, since they do not see us more." Some additional and specific mentee quotes are as follows; "I might go into engineering." And "It's made me think about doing something in the computer/engineering fields."

A general overview of qualitative data from the survey yielded similar support for the effectiveness of the mentoring program. Both mentors and mentees felt their academic success, learning, and interest in computer science had increased because of the mentoring. This was the main thrust of the comments. Additionally, both mentors and mentees reported that they formed good relationships that they valued. Both mentors and mentees wanted to spend more time together and to get to know each other better. This is the reason that the mentor visits were more frequent in Spring semester. Both mentors and mentees expressed confusion and frustration with the mentoring process in terms of providing support and tutoring. Along these lines, both felt more support should be given and less tutoring should happen. In other words, both wanted more emotional and social support and less academic tutoring. Both the mentors and mentees wanted to spend more time giving and getting advice and information about college, careers, and practical life issues. This is the purpose of mutual mentoring, bonding, and creating trust. Mentors also said that being able to help was a benefit and they felt that their role as a mentor was fun and fulfilling. The mentors also enjoyed activities when the roles were reversed and the mentees taught the mentors programming, specifically mentioning the process of mutual mentoring. For instance, some of the mentors were not familiar with the Dr. Racket language. They learned more about it the language by interacting with 11th grade students. The college student mentors enjoyed this very evidently mutual mentoring process. These results are in line with other studies that show professional and personal gains for college student mentors of younger children (Trepanler-Street, 2007). Mentors also perceived that the mentees who understood the material, increased their motivation over time. However, those who did not understand the material, decreased their motivation over time. In other words, high school students who understood the computer programming instruction increased their motivation for it. However, high school students who did not understand the computer programming decreased their motivation for it.

Educational and/or Scientific Significance

Learning to program computers is a challenging task, especially for underserved students who traditionally do not do well academically. The 11th grade students who participated in this project were from impoverished homes with parents who might not have attended college and might speak English as a Second Language. Moreover, a good number of the 11th grade students were ethnic minorities and females. Although mutual mentoring is relatively new as a mentoring concept, its potential to impact the learning of traditional underserved students is evident. Being based on reciprocal relationship networks, mutual mentoring has the potential to keep underserved students progressing and learning as they are taught to program computers. Mutual mentoring can also increase student valuing of computer science and related fields. This evaluation of the mentoring program demonstrates that mutual mentoring does indeed have a positive impact on the 11th grade mentees and the college student mentors. This is of importance, because the lack of participation in STEM fields by underserved students negatively impacts the field of computer science (Cassell & Slaughter, 2006). It is also important because of the positive impact on the student mentors.

The information from this evaluation has impacted the NSF project in the second year. During the second year mentor-mentee meetings will focus on emotional and social support more heavily. The mentors will spend more time giving advice and information about college, careers, and practical life

issues. They will also provide any emotional and social support that is needed. Their role as academic tutors will be lessened. This was the original intent of the program. However, during the first year the relative emphasis on the two roles was reversed which caused some frustration. It is the intent of the researchers to improve the mutual mentoring focus this year. However, it must be stated that the first year's mutual mentoring process was successful in enhancing the college mentor's and 11th grade mentee's valuing of computer science and related fields. The current evaluation evidence that is mentioned in this paper support the assertion of first year mutual mentoring success. The successful aspects of the mentoring program, such as advanced training, activities, events, and regular meetings during the academic year will continue in the second year. Indeed, the program leads hope to build on the first year success, by responding to the needs of the students and the results of this evaluation.

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References

Cassell, G. and Slaughter, J.B. (2006). The Challenge of the New Demographics of Higher Education: Increasing Women and Minority Participation in the STEM Disciplines. *Business Higher Education Forum 2006 Issue Brief.*

Forsbach-Rothman, T. (2007). The Mentor Role: Is Training Necessary? *Journal of In-service Education*, 33 (2) 245-247.

Fritzberg, G.J., and Alemayehu, A. (2004). Co-Narrating an Educative Friendship Between an Education Professor and an Urban Youth. *Urban Review: Issues and Ideas in Public Education,* 36 (4) 293-308.

Georgiou, S.N., Demetriou, A.P., and Stavrindes, P. (2008). Attachment Style and Mentoring Relationships in Adolescence. *Educational Psychology*, 28 (6) 603-614.

Giannantonio, C. M. (2010). Review of content analysis: An introduction to its methodology. *Organizational Research Methods*, 13 (2), 392-394.

Krippendorff, K. (2004). Reliability in content analysis: Some common misconceptions and recommendations. *Human Communication Research*, 30 (3), 411-433.

Liang, B., Spencer, R., Brogan, D., and Corral, M. (2008). Mentoring Relationships from Early Adolescence through Emerging Adulthood: a Qualitative Analysis. *Journal of Vocational Behavior*, 72 (2) 168-182.

Linnehan, F. (2001). The Relation of a Work-Based Mentoring Program to the Academic Performance and Behavior of African American Students. *Journal of Vocational Behavior*, 59 (3) 310-325.

Sorcinelli, M. and Yun, J. (2009). Finding a Mentor. *NEA Higher Education Advocate, 26* (5) 5-8

Treplaner-Street, M. (2012). Mentoring Young Children: Impact on College Students. *Childhood Education*, 84 (1) 15-19.