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## **AC 2012-3860: GRADUATE STUDENTS: INFLUENTIAL AGENTS OF SOCIAL CAPITAL FOR ENGINEERING UNDERGRADUATE RESEARCHERS**

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# **Graduate Students: Influential Agents of Social Capital for Engineering Undergraduate Researchers**

## **Abstract**

The STEM education community's research on undergraduate research experiences has shown that participation in a research experience has a positive influence on undergraduates. This study focuses on determining the role of graduate student mentors in the undergraduate researchers' development of availability, access, and activation of social capital resources related to research and academic/career plans. Using Lin's Network Theory of Social Capital, we surveyed and interviewed fourteen students taking part in a summer research program on a research intensive university campus. Results from the study indicate that graduate students served as unique and significant agents of social capital associated with plans to pursue academic/career plans related to research, specifically to attend graduate school.

## **Introduction and Background**

Undergraduate research experiences within engineering academic, industrial and national laboratory settings have recently received significant interest as a mechanism for attracting undergraduates to graduate-level work. While there are many formal and informal programs exist to provide undergraduates with research experiences during the academic year or summer, the REU program sponsored by the National Science Foundation (NSF) is one of the largest initiatives supporting undergraduate students in research in all of the areas of research funded by NSF. The National Science Foundation's Research Experiences for Undergraduates (REU) initiative aims to recruit students to careers in research and has funded over 1,700 sites totaling over \$435 million (of which over 600 sites receiving \$171 million in funding are presently active)<sup>1</sup>. Research by the STEM education community concurs that these research experiences have a positive influence on undergraduates in a variety of ways. Yet, many of the specific aspects of the nature benefits to participants and how they accrue to participants are not known or well understood.

Prior work by the first author used Lent's Social Cognitive Career Theory to study the impact of REU programs on undergraduate students' self efficacy for graduate school and research careers<sup>2</sup>. In this prior work, we found that graduate student mentors who work closely with students on their projects served as "coping models" in developing undergraduates' self-efficacy for research and graduate school. Specifically, we reported that the REU program served as a "taste" of graduate school, and gave participants access to graduate students and professors who served as both role models and sources of information about academic and career options. Several factors contributed to their reported increased in self-efficacy for graduate school and research careers: their accomplishments in the laboratory, new knowledge about graduate school and potential career options, and vicarious learning<sup>3</sup> that took place over the summer via their graduate student mentors. In particular, our prior work made the case for fostering formal and informal interactions between graduate students and undergraduate researchers and for including specific opportunities for participants to learn vicariously through coping models that they perceive to be similar to themselves.

In the present study, we use a different theoretical basis to study the potential benefits of graduate-undergraduate relationships during these research experiences: Lin's Network Theory of Social Capital<sup>4</sup>. A basic definition of social capital is *resources gained through relationships*. Portes compared social capital to other forms of capital, stating: whereas economic capital is in people's bank accounts and human capital is inside their heads, social capital inheres in the structure of relationships<sup>5</sup>. Building from prior work, where the importance of the *relationship* between undergraduate researchers and graduate students was demonstrated<sup>6</sup>, we chose social capital as the theoretical framework for the present study. The goal of this selection is to develop our understanding of the relationships between *undergraduate* research participants and *graduate* students participating with them in the research process and begin to identify what potential benefits students gain as a result of having access to this additional and unique social capital. We also seek to present our data and analyses in a way that allows for a degree of transferability<sup>7</sup> to other stakeholders who wish to gain insight about some of the specific and important aspects of designing and implementing effective programs (REU principal investigators, for example). Specifically, our hope is to provide insights into some of the mechanisms by which graduate students can serve as influential agents of social capital for engineering undergraduate researchers.

### **Network Theory of Social Capital**

Social capital theory originated in the sociology domain, and has a rich history of application in other fields, including education<sup>5</sup>. Conceptualizations of social capital emerged through the independent works of Bourdieu<sup>8</sup>, Coleman<sup>9</sup>, and Lin<sup>10</sup>. Lin's Network Theory of Social Capital, which examines social capital at the level of the *individual*<sup>4, 11-14</sup>, was adopted for this work. Lin defined social capital as "resources embedded in a social structure which are accessed or mobilized in purposive actions"<sup>11</sup>. This definition entails three essential elements, as identified in Table 1: availability, accessibility and activation of social resources<sup>4, 11, 14</sup>. Simply having a large social network (and presumed *availability* of resources) does not ensure that an individual has a large "volume" of social capital. The individual must also have sufficient *access* to the people in their social network that can link them to the needed resources, and must purposefully *activate*, or put those resources to work<sup>14</sup>.

Thinking of social networks as a pool of resources, most networks provide some redundancy. For example, a student may have multiple people in his or her network that can provide knowledge of the various procedures for a particular type of experiment when working in an engineering laboratory. However, the difference between having one person with access to the resources needed to achieve a goal (e.g. properly conducting the experiment) and no one in their social network with access to the resource can be the determining factor in success<sup>15</sup>. These various "agents" of social capital are a topic currently under study by the authors with regards to undergraduates' engineering major choices<sup>16</sup>, and typically include individuals such as parents, friends, teachers, significant others, and counselors/advisors. Here, we contend that the research experience and interactions with graduate students serve as "agents" who "fill holes" within undergraduates' social capital specifically related to graduate school and research careers in engineering, providing valuable resources to undergraduate engineering students that consequently make them feel more confident in their abilities as an engineer and more likely to pursue graduate studies and/or research careers in engineering. Thus, undergraduate research

programs can provide a unique form of social capital to undergraduate participants, because they likely would not have had this interaction with graduate students otherwise.

**Table 1. Essential Elements of Social Capital and Relevance to the Present Study**

| Element              | Definition from SC Theory  | Application to REU research   |
|----------------------|--|---|
| <b>Availability</b>  | Pool of resources available in one’s social network, such as economic, cultural, or human capital                        | The availability of resources related to engineering, research, and graduate school to a student through contacts they made as a result of the REU program, including faculty members, graduate students, peers, guest speakers, among others |
| <b>Accessibility</b> | Ease of access to resources depends on quality of relationships and frequency of interaction (termed “strength of ties”) | The nature of the relationship the student has with individuals possessing relevant resources needed to make decisions about research and graduate school in engineering  |
| <b>Activation</b>    | Purposive mobilization or use of the resources   | If/how a student puts those resources to work to make decisions about pursuing graduate school and/or research careers in engineering   |

### Research Question

What role, if any, do graduate students play in undergraduate researchers’ development of availability, access, and activation of social capital related to research and academic/career plans?

### Research Approach

Working with the social capital theoretical framework, we took a constructivist approach, asking participants to construct and assign meaning from their own memories and experiences as to who they felt were influential members of their social networks as they related to academic and career decisions at two distinct time points. These time points were (1) when the participant was deciding to pursue the REU program, and (2) after completing the REU program. Participants were asked to complete a “Name and Resource Generator” survey instrument which was adapted from prior work with engineering undergraduates’ social capital<sup>16</sup> and tailored to the summer REU experience. For each time point, participants were asked to generate a list of names of individuals who were influential to them, answer questions about the nature of these relationships, and then answer questions about their availability and access to a variety of resources related to research and graduate school in engineering (e.g. “gave me information about graduate school programs in my field”). These participants were then interviewed in person by one or two researchers. The surveyed responses were then used during interviews with the participants. The semi-structured nature of the interview questions allowed participants to elaborate on their individual survey responses, in addition to talking about other relationships and agents of social capital related to research and graduate school.

We chose the basic interpretive approach for qualitative research following that of Merriam<sup>17</sup> because we wanted to understand 1) the participants' experiences during a summer undergraduate research program, and 2) how they made meaning of their interactions with people in their social network, particularly those who became members of their network by way of their participation in the summer REU program. Caution was taken to limit researcher bias during analysis. As noted by Van Note Chism, Douglas, and Hilson<sup>18</sup>, the basic interpretive researcher is susceptible to altering their findings when not identifying their own biases, perceptions and assumptions. During this study, the authors assumed that each participant had a research experience which was positive from a social capital standpoint. However, we remained open to ways in which this might play out. All three authors initially individually explored each of the transcripts, and then discussed dominant themes noted by each. The questions in the semi-structured interview guide (and survey) allowed us to study the social capital of participants in prior to the REU experience, social capital agents at their home institutions, families, summer faculty mentors, program staff, program guest speakers and peers as new members of their networks. The results of this current research are also compared and contrasted with the first author's previous studies<sup>2, 6, 16</sup> with what our new data offers us in terms of rich descriptions of the undergraduate researcher-graduate student relationship.

## **Participants**

Our sample consisted of 14 undergraduate researchers participating an undergraduate research program on a research intensive university campus. Students in this program were either by funded by the National Science Foundation or a local research center. An active recruitment plan (phone calls to collaborators at non-research institutions and Historically Black Colleges and Universities, emails through student societies, website postings) resulted in diverse participant demographics: 50% female, 57% from a non-research intensive institution, 21% ethnic minorities. Approval was obtained from the Host University's Institutional Review Board.

## **Methods**

The study as a whole utilizes a mixed methods approach including a quantitative "Name and Resource Generator" (NRG) survey instrument and qualitative semi-structured interviews, which were briefly described in the Research Approach section. However, this paper focuses on the qualitative interview phase of the study, where we are reporting on and analyzing data from the interviews. Since the responses from the NRG instrument did inform the selection of interview questions, we will provide a brief explanation of the survey instrument.

The existing NRG survey instrument was modified slightly to cater to some of the resources and people more applicable to the REU program. Consistent with the previous deployment of this instrument, the modified NRG was tested in "think-aloud" sessions<sup>19</sup> where participants take the survey with the researchers present and talk out loud while taking the survey and thinking about their answers, so the researchers can be confident that the participants respond to survey items in a manner consistent with the intended design of the instrument (and if not, identify ways to improve the instrument to alleviate any potential misconceptions). The survey, which takes approximately 30 minutes to complete, was completed by 14 participants via the internet

(SurveyMonkey) at a time and place convenient for them during the last week of the REU program.

During the qualitative phase, the same summer research participants who completed the survey were then asked to participate in individual semi-structured interviews (all participants agreed). Ongoing and future work by the authors includes triangulation of the interview data with the NRG survey instrument. Such interviews are appropriate for the type of research being conducted; the NRG and authors' other work related to social capital is based on grounded theory methodology and specifically involves "studying a process, action, or interaction involving many individuals" <sup>20</sup> (p. 78). Interviews are often recommended as a way to obtain qualitative data that will "play a central role" <sup>20</sup> (p. 131) in the data collection and analysis efforts towards answering the research questions. In fact, "the detailed thick description, and the closeness of the researcher to the participants in the study all add to the value or accuracy of a study" <sup>20</sup> (p. 207). This data can later be mixed or triangulated with the quantitative NRG survey data, which provides additional evidence and support towards conclusions —"corroborating evidence from different sources to shed light on a theme or perspective" (p. 208)—often identifying potential areas for the results to be transferable<sup>20</sup>. "Rich, thick description allows readers to make decisions regarding transferability" based on shared characteristics between the detailed setting under study and the reader's (p. 209). During the interviews, participants described specific examples of social resources gained through the summer research. While these results are specific to the program under study, the presentation of the results is intended to allow the reader to relate and potentially transfer these results to other similar programs. Participants were prompted with questions about some of their specific survey responses (most commonly involving those about the specific people they listed in the name generator, and any interesting or unusual observations in their other survey responses) in order to gain additional detail and understanding about their survey responses and how the REU experience may have influenced their social capital related to graduate school and research careers in engineering. Interview transcripts were coded and analyzed using NVivo8, a software package for qualitative data analysis. Initial codes were developed based on Lin's aspects of social capital, and additional sub-codes were added as specific pertinent themes emerged.

## Results

### 1. Availability:

The structure of program inherently provided new agents of social capital for the undergraduate researchers during the 10-week summer program. Most participants interacted with a graduate student (an assigned mentor or other member of their laboratory group) frequently in the lab/office setting. In some cases, spending time individually with graduate students or as a group allowed for increased camaraderie and/or friendship development that helped participants become comfortable and learn from graduate students. Some participants also described weaker ties with other graduate students who still were significant to them and influential when it came to their academic and career plans. For example:

*Our lab group...we would go and eat lunch at pretty much 12:30 each day... and that was a good time of just hanging out and getting to know them and, I think we bonded pretty well over*

*the summer. For evidence of that we went out and saw the midnight premiere of Harry Potter all together. That was organized through our lab group. And we actually got some other kids from the REU to come with our lab group.*

## **2. Access:**

The strength of ties was evident from participants' descriptions of the nature (quality) of the relationship as well as the frequency of interaction.

One participant talked about initially worrying that he/she would not fit in:

*I was actually very scared [about research]. I didn't know if I would add up so to speak, you know. I didn't know where, where I would fit in. How far along I would be or if I would be so far behind that I couldn't accomplish anything. And no one ever made me feel inadequate. They all understood that I haven't graduated yet, everyone feels this way, you know, you fumble around lab for a week or two because you don't know where anything is, and you get comfortable with that environment.*

Another emphasized how the whole research group chipped in to help him/her and others in the group out when they needed it:

*I think that every single person in my lab group has helped me out on my project at, at least one point. And that is, I'm usually a, I just want to do it myself kind of person, but that's been really great. And I think if I did research I'd want to work in a lab group like that. It's very much a give a little, take a little with everyone which is really pretty neat.*

Another participant described his/her graduate student as a "go-to person" with whom they had contact everyday:

*And every time I had a question they pretty much got right on helping me like they would drop what they were doing even though I just asked them whenever you're done – they would usually just drop everything anyway and come and help me. They were very helpful...so I mean, [I] interact with her everyday probably every hour and she's been awesome. She gives a lot of advice about academic, you know, career stuff, and so that's really nice...*

Another participant valued the informal interaction as well as the things learned in the lab from his/her graduate mentor:

*And [Name], was, she was just an excellent grad student all around. She taught us the ropes, she showed us around the lab. And if we ever...had any questions...[I'd] go to her and she'd talk to us about it. She ate lunch with us every day, took us out to a couple places that she knew of... But it was a very, it was very nice to have someone who I could just informally talk about the research with and discuss, you know, people in a lab group talk about whatever. [Question:]. So if you had a question or needed some help, was she available to do that? [Answer:] All the time.*

The daily close proximity (either in the lab or office) of the graduate students working alongside the undergraduate REU participants was beneficial to forging strong ties and identified as one way of ensuring that available resources are accessed, and ultimately activated:

*Yeah, I've interacted with him [graduate student in my research group] a lot. He's always like in the office and talking to other people and just seeing how everything, everyone's individual projects are going which is pretty neat to see that kind of interaction and kind of get a little bit of what everyone else is doing..... Every time I had a question he as there and able to help me.*

### **3. Activation:**

Undergraduate research participants described many scenarios where they derived information and resources from their relationship with graduate students. For example, many were curious about the academic path of the graduate students with whom they worked and also wanted to receive feedback, resources or information related to their own academic and career plans. For example:

*Actually yesterday I was talking to [Name of graduate student] and she was telling me about how like, she's in [engineering discipline] like me, and she's going for a Masters and she was telling me how she's having trouble finding a job now because a lot of places want like bachelor's or Ph.D. ... For awhile I wanted to go to grad school to get my Masters, now I mean, I'm still deciding. I've always been like on the [fence], couldn't decide between what I wanted to do, but, just like listening to other people's experiences really helps.*

Another participant spoke of their graduate student mentors' career path and how he/she had learned from it:

*She's going for her Ph.D. though and, I think ultimately she wants to be a professor so she definitely has a different life plan than I want but she definitely showed me at least one option with where to go after this.*

Another student frequently sought out answers to his/her questions:

*I want to know more about the engineering fields and try to just see how that fits with what I want ...so that's been a lot of my questions for her and other people in my research group [Question] So have they been able to answer those questions or point you towards other resources? [Answer] Oh, yes. Yeah, they've been great. If they don't know the answer they tell me someone to go ask.*

Another expressed a similar sentiment and was interested in the life stories of the graduate students:

*... it's really good to talk to them [the grad students], [to ask] what do you actually do in grad school and what do you, how did you end up here?... And then like I guess the majority of them are Ph.D. students and I was like well, what's the difference like what, why did you choose Ph.D. over this, what do you want to do eventually?*



For the most part, participants also felt comfortable talking to the graduate students about their personal lives and plans, especially when the graduate students were willing to share their own personal experiences. These conversations often helped the REU participants learn about potential career paths that were previously unknown or inaccessible:

*Well, I haven't worked with [Name of graduate student in research group] just too much but we spent a day with the [type of equipment] which was a nightmare, but, it was good to see him work there. And we went to lunch afterwards and he, we had a really in depth conversation. He told me why he was choosing to leave industry and go into academia and that's another question I had been having and so he was very good and open about his decision, for his career and so I really enjoyed getting to speak to him. I was really excited to know that you're not stuck in one or the other because I mean, he explained where he was at and how he could switch over from industry to academia easily and he said that the inverse is also true. He's ...kind of a life mentor in a way.*

Participants also described in detail how graduate students had been their link to knowledge and resources about the technical aspects of “the day-to-day research process”, laboratory equipment, research protocols, and even learning the cultural norms about how research groups function. One participant talked about learning both specific aspects of communicating their research results and general lab knowledge:

*They're mostly just helpful a lot in keeping me grounded and helping out with the different things that I had – like the abstracts that I was writing this summer and especially like [Name] sat down with us and we put our research posters up on a projector screen and we kind of looked through them and you know, fixed the little grammar mistakes and make sure the formatting was right and they gave us tips .... [Name] was definitely more of the go-to person for the details of like what I'm actually doing but they [the other students] are helpful with anything that was sort of generally research-related or lab-related. I mean they know where stuff is in the lab so if I can't find something they can help me figure out where to find it.*

Another participant discussed their graduate students' role in teaching him/her how researched “worked” and not to get discouraged:

*[The graduate student would say] don't forget if a machine breaks that's part of research. Like and my research project was stalled out for about a week and a half over the summer because one of my machines broke and that's, I'm not exactly sure how I would have handled it if I hadn't, if she hadn't sort of been giving me an example to follow. But she [said], all right, let's see what we can do about it. Okay, we can't do anything, who can we call about it? Okay, let's call these people, figure out what needs to be done and just sort of step-by-step process of all right, let's try and get this thing back on track as soon as we can but not like freak out and try and get it back on tomorrow just, you know, processed a very logical way of you know, solving the problem and not freak out about the fact that you're sitting around in the lab and don't have much to do for a week.*

One participant succinctly stated:

*They teach you the ropes, so to speak.*

Having graduate students in their network helped participants understand (either through specific activation of social capital or observation/availability of having graduate students around) graduate school was like. One participant observed:

*When they first get there, you don't know anyone, you don't know where anything is, but then you start to feel more comfortable and people get to know you and you start to joke around and you see them stressing out one day and then you see them really happy [the next] because something is successful, so you see the mood swings in the graduate student, and I think that's one of the biggest things that I can relate to. I get stressed out myself and they just show you that hey, you know, this is research, nothing ever goes as planned so if you can learn to not expect anything that's the best way to go.*

Another student said, when asked if they felt like they had gotten a sense for what life as a graduate student would be like, replied:

*I'm not sure if they were just hiding it but they had a lot of fun and you know, some grad students tell me it's really stressful but they looked like they just enjoyed [it], maybe it's because they enjoyed what they were doing, it wasn't that stressful to them.*

Another compared this experience to a past experience where there was little interaction with graduate students:

*Well, it's been really good to see this research group because last summer [in another program] it was kind of just me and my mentor and occasionally a couple of grad students...and it wasn't, wasn't enjoyable interaction, it was really kind of forced, but this year I mean it's like your research group is, you know, who you spend a lot of time with and you know you can have fun with them even if it's during research hours because you have down time. And so it was just kind of a reassurance that, you know, research can be an enjoyable experience.*

Participants also gained knowledge about “life as a graduate student” from observation:

*Well, I think it's fun seeing like how hard they work sometimes, like wow, this is what grad school is. I mean they do make me want to go to grad school, but like seeing just how you know, they works – I really need to think about this because I see them in the lab 24/7 staring at things and doing graphs, you know. [Question:] What else have you learned about, or you know, what are your perceptions now about life as a grad student after having been with these, these three and maybe other grad students for the summer? [Answer:] It's definitely not easy but it's doable.*

And

*Kind of just being in the environment, seeing like witnessing a day in the life of grad students and ...it, can be really rough and has these ups and downs and enthusiasm and productivity but*

*actually seeing it and interacting with Ph.D. students I'm like oh yeah, they do still have a life and they worked a lot, too, but they're not – like they're relatable people.*

## **Discussion**

Our results indicate that graduate students served as unique and significant agents of social capital associated with plans to pursue academic/career plans related to research, specifically to attend graduate school. We acknowledge that the current study focuses on benefits derived from an increased social network accessed and activated by participants, rather than constructive criticism or formative assessment of the program; these are aspects that we anticipate addressing in future papers. Our perspective of focusing on the benefits of undergraduate research builds on the aforementioned prior work and that of other researchers<sup>2, 6, 21-23</sup> who have focused on other benefits of undergraduate research such as career preparation and validation of career goals, recruitment to graduate school and professional skill gains.

A discussion of results would not be complete without acknowledgement of potential researcher bias. While this study was built on prior results by the first author, a conscious effort was made during the analysis to avoid “seeing what we wanted to see in the data”. In fact, a couple of participants talked about lack of availability which should be acknowledged; their assigned mentor was not as helpful as the undergraduate researcher wished, although other graduate students stepped in to help, resulting in an overall positive experience. In one case, the assigned mentor was out of town quite a bit. While initially disappointed and confused, the participant viewed the absences in hindsight as one of the things that pushed help him/her to gain independence in the lab.

Also, it should be acknowledged that there are other important social capital agents that we found, namely faculty mentors, program staff and guest speakers—these were also coded in the analysis and will be described in depth in a future paper. Participants discussed these as agents of social capital but the uniqueness of the undergraduate researcher-graduate student relationship lay in the *strength of ties of these relationships*. The focus of this paper was delimited to the unique nature of the graduate student as an agent of social capital because of the high importance participants themselves placed on these relationships and network members. Participants described how being around the graduate students, working with them, and observing them allowed them to see first-hand what life as a graduate student was like—a finding consistent with our 2008 paper that concluded that graduate students serve as means of vicarious learning<sup>2</sup> for the undergraduate researchers. Even though most participants were happy with their relationship with their faculty mentor and looked up to them as role models, stronger ties with graduate students, forged both in and out of the lab, increased undergraduates' availability, access and activation of research-related social capital.

We performed some initial triangulation with the Name and Resource Generator instrument—specifically, (1) the number of graduate students listed in Name Generator section of the survey, and (2) the types of non-graduate student names listed.

- 12 of the 14 participants specifically mentioned graduate students
  - 4 participants listed one graduate student
  - 6 participants listed two graduate students

- 3 participants listed three graduate students
- 2 participants did not list graduate students but talked about them in their interviews
- 10 of the 14 participants also listed faculty mentors as being significant
- 6 of the 14 listed program staff (the PI and co-PI)
- 5 of 14 participants listed other REU students or other undergraduates in their lab
- 1 listed a guest speaker, although when specifically asked about this in the interviews, nearly all participants mentioned a specific speaker (the same one) that “filled a hole” in their network by providing specific information about careers in industry following graduate work
- 2 of the 14 listed a professor at their home institution who they consider to be a mentor

This initial triangulation supports our conclusions that graduate students are important agents of social capital for undergraduate researchers, and also points to additional agents such as faculty research mentors, peers, and program staff. Future work will involve further triangulating these interview data with additional survey items study to reveal further information about the influence of graduate students, as well as the undergraduate research experience as a whole.

## **Implications**

When designing a summer research program, our data suggest that the choice of graduate student mentors is equally as important the choice of faculty mentors, yet principal investigators rarely consider this when developing an REU program. While this study indicated that positive relationships between summer mentee and graduate student mentors can happen “naturally” in many cases, the importance of interactions with graduate students (whether considering it from a social cognitive viewpoint<sup>2</sup>, a skills gained viewpoint<sup>6</sup>, social capital, or other lens) warrants attention for principal investigators and participating faculty in the planning and implementation of undergraduate research experiences. Principal investigators for NSF REU programs have employed several strategies that emphasize the important role that graduate students assigned to mentor undergraduates and help the graduate mentors take ownership of their role, including: offering nominal stipends<sup>24</sup>, ensuring that the undergraduate project closely relates to that of the assigned graduate student<sup>24</sup> and requiring special workshops/classes on the importance of mentoring<sup>25</sup>.

Finally, we advocate open discussion between and among faculty and *all* graduate students who will be interacting with undergraduate researchers about the important role they could play in an undergraduate researchers’ academic and career decisions, whether this occurs on a formal role, a daily basis or occasionally throughout the research project. While the importance of graduate students as mentors has been acknowledged<sup>26</sup>, our research shows that it is not just the “formal” mentoring role that is significant for undergraduate researchers.

## **Acknowledgments**

The authors gratefully acknowledge the support of the National Science Foundation Grant# DMR-1062873.

## Bibliography

1. National Science Foundation (2011). *NSF – Award Search*. [Search terms: “REU” in titles; “REU” and “engineering” in titles or abstracts.] Accessed October 1, 2011, from <http://www.nsf.gov/awardsearch>.
2. Trenor, J. M., & Pierrakos, O. (2008). Utilizing a social cognitive theoretical framework to investigate the influences of a summer undergraduate research experience on participants' academic and career plans. *Proceeding of the 2008 American Society of Engineering Education Annual Conference and Exhibition.*, Pittsburgh, Pennsylvania.
3. Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, N.J.: Prentice-Hall
4. Lin, N. (2001). *Social capital: A theory of social structure in action*: Cambridge University Press.
5. Portes, A. (1998). Social Capital: Its Origins and Applications in Modern Sociology. *Annual Review of Sociology* (24), 1-24.
6. Trenor, J. M., Yu, S. L., Grant, D. S., & Salem, H. (2009). Participation in a research experience for teachers program: Impact on perceptions and efficacy to teach engineering. *Proceedings of the 2009 American Society for Engineering Education Annual Conference and Exhibition*, Austin, Texas.
7. Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.
8. Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). Westport, CT: Greenwood Press.
9. Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94 (Supplement: Organizations and Institutions: Sociological and Economic Approaches to the Analysis of Social Structure), S95-S120.
10. Lin, N. (1982). Social resources and instrumental action. In P. V. Marsden & N. Lin (Eds.), *Social Structure and Network Analysis* (pp. 131-145).
11. Lin, N. (1999a). Building a network theory of social capital. *Connections*, 22(1), 28-51.
12. Lin, N. (1999b). Social networks and status attainment. *Annual Review of Sociology*, 25, 467-487.
13. Lin, N. (2000). Inequality in social capital. *Contemporary Sociology*, 29(6), 785-795.
14. Lin, N. (2008). A network theory of social capital. In D. Castiglione, J. v. Deth & G. Wolleb (Eds.), *Handbook on social capital* (1st ed., pp. 50-69). New York: Oxford University Press, Inc.
15. Van Der Gaag, M. P. J., & Snijders, T. A. B. (2003). *A comparison of measures for individual social capital*. Paper presented at the Creation of and Returns to Social Capital. Retrieved from [http://www.xs4all.nl/~gaag/work/comparison\\_paper.pdf](http://www.xs4all.nl/~gaag/work/comparison_paper.pdf).
16. Trenor, J.M., Gipson, K., and Miller, M.K. (2011). Developing a Survey Instrument to Characterize Social Capital Resources Impacting Undergraduates' Decisions to Enter and Persist in Engineering. *Proceedings of the 2011 Frontiers in Education Conference*, Rapid City, South Dakota.
17. Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco: Jossey-Bass.
18. Van Note Chism, Douglas, and Hilson (2008). *Qualitative Research Basics: A Guide for Engineering Educators*. Accessed from [http://cleerhub.org/resources/9/download/RREE\\_Qualitative\\_Research\\_Handbook\\_ChismDouglasHilson.pdf](http://cleerhub.org/resources/9/download/RREE_Qualitative_Research_Handbook_ChismDouglasHilson.pdf)
19. Trenor, J.M., Miller, M.K., and Gipson, K. (2011). Utilization of a Think-Aloud Protocol to Cognitively Validate a Survey Instrument Identifying Social Capital Resources of Engineering Undergraduates. *Proceedings of the 2011 American Society for Engineering Education Conference and Exhibition*, Vancouver, Canada.
20. Creswell, J.W. (2007). *Qualitative Inquiry & Research Design: Choosing Among Five Approaches* (2<sup>nd</sup> ed). Thousand Oaks, CA: Sage.
21. Russell, S.H. (2005). *Evaluation of NSF support for Undergraduate Research Opportunities: Survey of STEM graduates (Draft Final Report to the National Science Foundation)*. [Accessed 2007 March 17, 2007]; Available from: <http://www.sri.com/policy/csted/reports/>.
22. Russell, S.H., M.P. Hancock, and J. McCullough (2007). *The Pipeline: Benefits of Undergraduate Research Experiences*. Science Education, p. 548-549.
23. Hunter, A.-B., S. L. Laursen and E. Seymour (2007). *Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal and Professional Development*. Science Education, 9(1), p. 36-74.

24. Humphreys, S.M. (1997). Teaching and Learning in an Era of Change. *Proceedings of the Frontiers in Education 27th Annual Conference. (IEEE Cat. No.97CH36099)*, p 1137-9
25. Husson, S., Clemson University, personal communication.
26. Hartke, S.G., Isaksen, D.C., and Wood, P.M. (2006). Graduate Students as Mentors in Mathematics REUs. *Proceedings of the Conference on Promoting Undergraduate Research in Mathematics*, Chicago, Illinois.