Mentor and Undergraduate Student Comparisons of Students' Research Skills

Monica F. Cox and Angie Andriot
Purdue University

Abstract

This paper introduces preliminary results that include both graduate mentor ratings and faculty mentor ratings of undergraduate students' self-reported assessments of their research experiences. In addition, researchers examined how these ratings differed under four circumstances: (1) the quality of the mentoring relationship, (2) the amount of mentor and student time spent together, (3) the frequency with which the student asked his/her mentor for help, and (4) the amount of control the faculty mentor had over student projects. Results show that students rate their own abilities and skills higher than do their faculty mentors. Authors also noted the greatest discrepancies between faculty and student ratings in situations where the mentoring relationship quality was high, the amount of time spent together was little, the students rarely went to the mentor for advice, and the faculty exerted little control over the student. Suggestions for additional studies exploring the impact of mentoring within undergraduate research are provided.

I. INTRODUCTION

Seymour et al. [1] define undergraduate research as "undergraduate engagement in authentic research conducted in intensive summer-long program under the direct supervision of faculty researchers [1, p. 494]." These faculty researchers, however, may differ in their mentoring styles, their experiences working with undergraduates, and their philosophies of conducting research. In addition to faculty mentoring differences, variances in students' technical abilities and students' understanding of the research process may affect students' summer research experiences [2]. This is especially of interest to mentors and students in hands-on fields such as engineering and technology.

Although numerous studies have reported the positive influence of undergraduate research experiences upon students' decisions to pursue post-graduate careers in science, technology, engineering, and mathematics (STEM) [3,4], students' decisions to pursue graduate studies [5,6], students' persistence to graduation [7], and minority students' persistence within STEM fields, few studies compare faculty and graduate mentors' views of undergraduate students' experiences to students' self-reported ratings of their experiences.

The current paper builds upon two studies—one that explored comparisons between undergraduate students' and faculty mentors' ratings of students' research expertise at the end of a research experience [8] and another that examined undergraduate students' extrinsic and intrinsic motivations for participating in a summer undergraduate research program within a Midwest research university [9]. Within her study, Kardash [8] found that (1) undergraduate research students thought that they had increased their research skills during their undergraduate research experiences and that (2) faculty mentors' ratings of students' abilities to conduct research were similar to undergraduate students' ratings of their research skills. The students, however, often overestimated their research abilities.

The authors [9] discovered that during the course of a summer research program, the overall student self-ratings were *lower* at the end of the program than at the beginning of the program. One reason for this decreased confidence in abilities may have been students gaining a greater awareness of what research entails. Before the program, they may have been overly confident in their abilities, but afterward they may have realized that research was harder than they had previously believed. Students, having come to this understanding, also may have been still overly confident in their abilities to complete certain tasks. Perhaps those tasks in which there were still discrepancies were tasks in which students gained the least experience during the program.

Both studies, however, did not include information about the role of graduate students within undergraduate students' research experiences. For this reason, the current study introduces preliminary results that include both graduate mentor ratings and faculty mentor ratings of undergraduate students' self-reported assessments of their research experiences. More specifically, the research questions of interest within this study include the following:

1. Do students' self-evaluations of their levels of research skills at the end of the summer program differ significantly from their faculty and graduate student mentors' evaluations of those same skills?
2. Does the amount of time students and faculty spend interacting with each other account for any of the differences in evaluation?
3. Does the quality of the mentoring relationship correlate with differences in student and faculty evaluations?
4. Does the amount of help students ask for during their experiences correlate with faculty and student differences in evaluations?
5. Is there any association between faculty and student evaluation and the level of control the students felt the faculty had over their work?

II. RESEARCH METHODOLOGY

A. Participants

To complete this study, survey data were gathered from 124 undergraduate student par-

ticipants, 58 graduate student mentors, and 96 faculty mentors in Purdue University's Summer Undergraduate Research Fellowship (SURF) program during summer 2006. The goal of this eleven-week summer program is to expose STEM students to undergraduate research experiences that will allow them to "strengthen integrated, research-related, hands-on learning through discovery" [10]. In addition to conducting research, students engage in social activities, attend research and professional development seminars, and present their research at an end-of-program research conference that is attended by university students, faculty, and administrators. Overall, the SURF student sample was very diverse. Twenty-four percent of participants were not Purdue University students, and 34% of the students were international (i.e., were not United States residents). In addition, 30% of participants were female, and 14% were underrepresented minorities (i.e., African-Americans, Hispanic-American, or Native Americans). Approximately 94% of all SURF researchers were engineering majors [9].

B. Faculty Mentor, Graduate Mentor, and Undergraduate Student Surveys

At the conclusion of the SURF program, a survey exploring SURF students' research abilities was administered to both faculty and graduate student mentors participating in the SURF program. This survey contained twenty items rated on a 4-point scale where 1=disagree,

2=somewhat disagree, 3=somewhat agree, and 4=agree (Table 1). Mentors also had an option to reply "not applicable." Surveys were administered on-line, and mentors were recruited to participate in the study via an e-mail. SURF students completed a similar survey in the absence of their faculty and graduate student mentors at the end of the SURF program. Building upon the work of Kardash [8], SURF evaluators created and distributed this survey to faculty mentors and graduate student mentors to measure the extent to which the mentors agreed or disagreed with SURF participants' perceived gains during their research experiences.

Also included in the current study are four items from the end-of program survey that was administered to SURF undergraduate students. These items relate to the quality of students' mentoring relationships with faculty, the amount of students' time spent within their faculty mentors, the frequency with which students asked their faculty mentors for help, and the amount of control faculty mentors had over student projects.

C. Analysis of Data

The data were analyzed using SPSS software. We compared student self-evaluations to faculty mentor and to graduate mentor evaluations by examining the mean differences in responses. Independent samples t-tests with a 95% confidence interval were used to test for statistically significant differences between the groups.

III. RESULTS

A. Student Self-Evaluations Compared to Faculty Mentors

At the end of the research program, students were most confident in their abilities to relate well to people of different races, cultures, or backgrounds, and they were least confident

I am confident in this SURF student's ability to...
1. Learn lab/field techniques (e.g. instrumentation, measurement)
2. Apply critical thinking and problem-solving skills in an authentic research experience
3. Analyze data using statistics or math formulas within a theoretical/conceptual framework
4. Integrate engineering or science theory and practice
5. Learn new software packages
6. Learn contemporary concepts in his/her research area
7. Frame a specific research question
8. Formulate a research hypothesis based on a specific question
9. Design an experiment or a theoretical test of the hypothesis
10. Observe and collect data
11. Interpret data by relating results to the original hypothesis
12. Understand the ethical implications of his/her research
13. Relate results to the "bigger picture" in his/her research area
14. Retrieve information from the library and internet
15. Present technical work effectively
16. Explain technical work to someone who is not a scientist or engineer
17. Write a scholarly article for publication
18. Work effectively with others on a team
19. Relate well to people of different races, cultures, or backgrounds
20. Listen effectively

Table 1- Items on Faculty Mentor and Graduate Mentor Surveys

I am confident in my/ the student's ability to…	SURF Student		Faculty Mentor	
	M	*SD*	*M*	*SD*
Relate well to people of different races, cultures, or backgrounds	3.88	0.35	3.87	0.42
Observe and collect data*	**3.84**	**0.41**	**3.72**	**0.58**
Learn lab/field techniques (e.g. instrumentation, measurement)	3.80	0.4	3.67	0.75
Retrieve information from the library and internet*	**3.79**	**0.43**	**3.66**	**0.66**
Listen effectively*	3.78	0.49	3.64	0.77
Work effectively with others on a team	3.76	0.43	3.79	0.59
Learn contemporary concepts in my research area*	**3.75**	**0.43**	**3.58**	**0.83**
Interpret data by relating results to the original hypothesis**	3.66	0.56	3.48	0.78
Learn new software packages	3.64	0.61	3.72	0.62
Relate results to the "bigger picture" in my research area**	**3.62**	**0.58**	**3.40**	**0.81**
Apply critical thinking and problem-solving skills in an authentic research Experience	3.58	0.63	3.46	0.85
Integrate engineering or science theory and practice	3.53	0.59	3.47	0.85
Frame a specific research question**	**3.52**	**0.58**	**3.29**	**0.84**
Design an experiment or a theoretical test of the hypothesis***	**3.52**	**0.62**	**3.18**	**0.84**
Formulate a research hypothesis based on a specific question**	**3.50**	**0.56**	**3.26**	**0.86**
Understand the ethical implications of my research	3.49	0.77	3.58	0.73
Explain technical work to someone who is not a scientist or engineer	3.47	0.65	3.42	0.85
Present technical work effectively	3.43	0.62	3.46	0.79
Analyze data using statistics or math formulas within a Theoretical/conceptual framework	3.41	0.65	3.41	0.82
Write a scholarly article for publication**	**3.20**	**0.77**	**2.92**	**0.96**

*p<.05, **p<.01, ***p<.001

Table 2: Student and Faculty Mentor Ratings of Ability at End of Program

in their abilities to write an article for scholarly publication (Table 2). Interestingly, even though this was the area in which the students were least confident, their faculty advisors were even less confident in their students' abilities. Overall, the faculty mentors' ratings of students' abilities differed significantly from the student ratings on seven tasks: (1) observing and collecting data, (2) listening effectively, (3) interpreting data, (4) framing a research question, (5) relating results to the "bigger picture," (6) designing an experiment or theoretical test of a hypothesis, and (7) writing a scholarly article for publication. In each of the instances, the faculty rated the students lower than the students rated themselves. Although the lower ratings by faculty are consistent with Kardash's [8] study, the current study notes seven measures with significant differences in student and faculty ratings of students' abilities. Within both studies, faculty reported students' inabilities to connect to the "bigger picture" of research.

B. Student Self-Evaluations Compared to Graduate Student Mentors

When comparing the student evaluations of themselves at the end of the program to those of the graduate student mentors, a slightly different outcome appears (Table 3). This time, only one item, "I am confident in my/the student's ability to relate results to the 'bigger picture' in my research area" is significantly different. As with the comparison to faculty mentors, students rate their own abilities higher than do their graduate student mentors. However, it would be misleading to compare the two tables based on number of significant effects. Since there were fewer graduate student mentors in the study, the power needed to arrive at a statistically significant difference is higher. For example, in the table comparing graduate student and faculty ratings, mean differences of 0.12 are significant at the 0.05 level. Although twelve differences between students and graduate student mentors are 0.12 or above, only one is significant. What we can examine, however, are the direction of the differences. On the majority of the items, undergraduate students rate themselves higher than their graduate student mentors rate them. However, students rated themselves equally or lower on relating well to people of different races, cultures, or backgrounds; observing and collecting data; working effectively with others on a team; and understanding the ethical implications of their research.

C. Mentor-Student Interactions and Quality of Mentoring Relationships

To further explore some of the reasons the student self-ratings would differ from faculty ratings, we examined how these ratings differed under four circumstances: (1) the quality of the

I am confident in my ability to…	SURF Student		Grad Student Mentor	
	M	*SD*	*M*	*SD*
Relate well to people of different races, cultures, or backgrounds	3.82	0.46	3.82	0.56
Learn lab/field techniques (e.g. instrumentation, measurement)	3.81	0.40	3.58	0.85
Retrieve information from the library and internet	3.78	0.47	3.51	0.81
Learn new software packages	3.74	0.64	3.68	0.74
Observe and collect data	3.74	0.51	3.80	0.63
Listen effectively	3.69	0.67	3.58	0.81
Work effectively with others on a team	3.60	0.60	3.69	0.76
Learn contemporary concepts in my research area	3.60	0.59	3.50	0.99
Relate results to the "bigger picture" in my research area*	**3.60**	**0.59**	**3.25**	**0.95**
Apply critical thinking and problem-solving skills in an authentic research experience	3.57	0.74	3.31	1.07
Present technical work effectively	3.55	0.64	3.30	0.99
Explain technical work to someone who is not a scientist or engineer	3.50	0.75	3.38	0.95
Interpret data by relating results to the original hypothesis	3.50	0.70	3.39	0.96
Frame a specific research question	3.47	0.76	3.21	1.02
Integrate engineering or science theory and practice	3.43	0.55	3.38	1.03
Design an experiment or a theoretical test of the hypothesis	3.42	0.81	3.28	0.91
Formulate a research hypothesis based on a specific question	3.38	0.67	3.18	1.00
Analyze data using statistics or math formulas within a theoretical/conceptual framework	3.35	0.72	3.22	1.06
Understand the ethical implications of my research	3.16	0.97	3.45	0.96
Write a scholarly article for publication	3.10	0.91	2.90	0.99

*p<.05, **p<.01, ***p<.001

Table 3: Student and Graduate Student Mentor Ratings of Ability at End of Program

mentoring relationship, (2) the amount of faculty mentor and student time spent together, (3) the frequency with which the student asked his/her faculty mentor for help, and (4) the amount of control the faculty mentor had over student projects. Since each of these questions was asked of the students, they are measures of student perception of each relationship characteristic. First, students' self-reported evaluations and faculty's ratings of their students' research skills were compared to the students' ratings about the overall quality of their relationships with their faculty mentors. Mentoring quality was rated on a four-point Likert scale where 1=poor, 2=decent, 3=good, and 4=very good. Trends show that there is a larger difference in student and faculty mentor ratings when the relationship quality is high (Figure 1). In such relationships, students rate their own abilities as lower than those students who report low quality relationships with their faculty mentors. However, the opposite effect occurs for the mentors: they are more likely to rate their student as high in the *high* quality relationships.

Second, students were asked how much time they spent with their faculty mentor. Again, evaluation of the student was broken down according to those who spent more and less time with their mentors (Figure 2). There was a greater discrepancy between the student self-ratings and faculty ratings in those instances in which the student and mentor had little contact. The biggest reason for this difference is that faculty rated their students much lower when they had not seen the students often. Interestingly, students who did not meet often with their mentors also rated their research abilities lower, although the difference was not as great. This finding indicates that faculty mentors are not

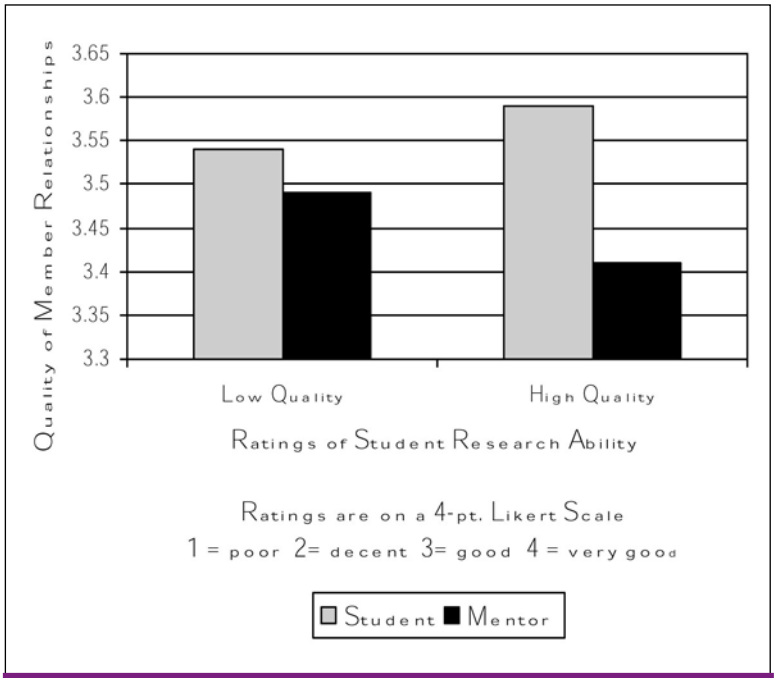

Figure 1. Perception of the Quality of the Mentoring Relationship Compared to the Ratings of Student Research Ability

seeking out their students when they think that the student is not doing well; that impetus they put on the student.

Third, the researchers noted differences between students who asked their faculty mentors for help versus those who did not. Although there is almost no difference in faculty versus student ratings for those who ask their mentors for help often, there is a difference for those who rarely go to their mentors for help (Figure 3). In the latter case, students rate themselves much higher than do their faculty mentors. This indicates that those students who do not go to their faculty for help are operating under false assumptions that they are making satisfactory progress as researchers. Based on the previous finding regarding time spent together, we can also gather that those faculty mentors are not doing anything to challenge these students' false levels of confidence.

Finally, we examined whether there were any differences in ratings based on how much control over the students the faculty mentor had. For this paper, faculty control refers to the extent to which students were able to develop their other research projects and decide what research they would conduct during the summer. Interestingly, the faculty rated *lowest* those students they controlled the *least* (Figure 4). Although students in low-control mentoring relationships also rated themselves lower, the difference was not as large. This provides further evidence that faculty are spending the most time mentoring those students they rate as higher on measures of research skill and competence. Those students who need the most mentoring are not getting faculty attention, partially because those same students do not feel they need the help from their faculty mentors.

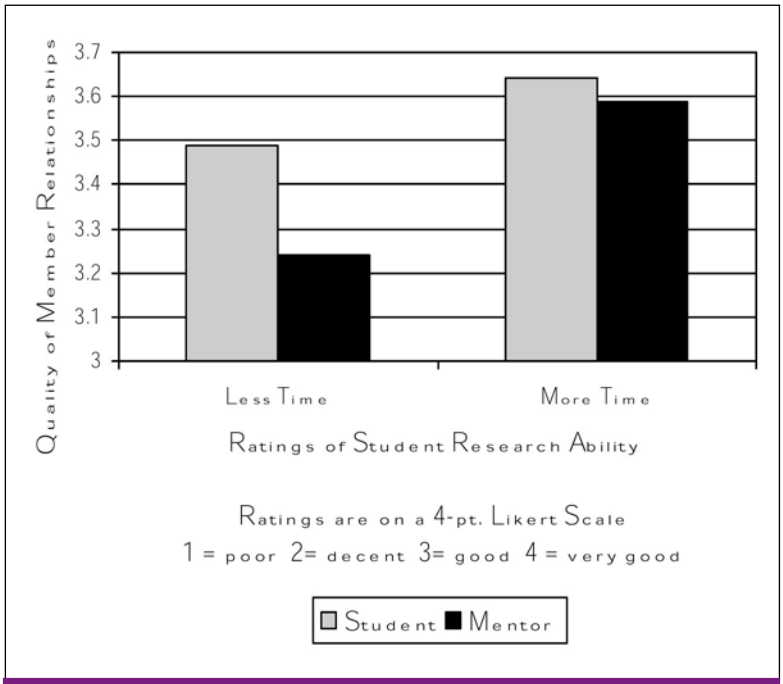

Figure 2. Perception of the Time Spent with Mentor Compared to the Ratings of Student Research Ability

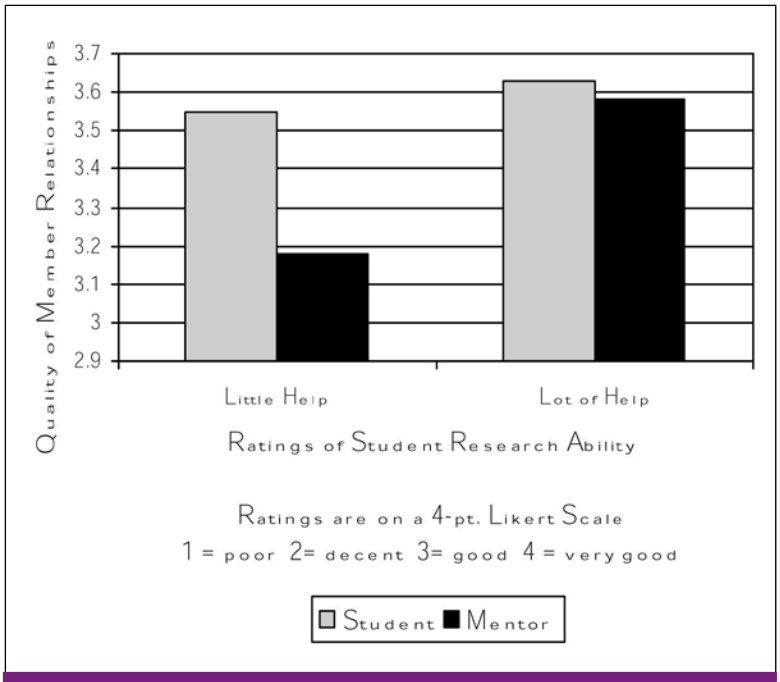

Figure 3. Perception of How Often Student Asked for Help Compared to the Ratings of Student Research Ability

IV. DISCUSSION

Within this study, both graduate mentors and faculty mentors agreed that their undergraduate students had difficulties relating their results to the "bigger picture" in their research areas. This is not surprising, since approximately 78% of participants had one year or less of research experience prior to the summer that mentors rated them [9]. This implies that engagement in research for three months might not have introduced students adequately to research topics and might not have given students opportunities to understand fully where their projects fit into the research programs of their faculty or graduate mentors.

Another concern about research relates to

the depth and breadth of a research experience. For example, since students enter programs with varying levels of research expertise, expectations about research, and interests in research beyond their summer experiences, a "one-size-fits-all" model of research may not be feasible. This conclusion aligns with the authors' research [9] noting that students' motivations for conducting undergraduate research differed initially, and as a result, their views about what they gained from their experiences might be different by the end of the research program. In addition, faculty mentors' ratings of their students may be a reflection of ideal traits that mentors want to see within their undergraduate research students, while graduate mentors' ratings more closely reflect what they see within the undergraduate students with whom they are working. Further research is warranted in order to analyze these potential differences. Thorough assessments of students' research skills at the beginning of a research experience might allow both faculty and graduate mentors to rate students' gain in research expertise accurately by the end of an experience.

Although no statistically significant differences were found between students' and faculty mentors' ratings of research experiences and the four variables mentioned in Section III, Figures 1-4 display trends that warrant further study. Students who spent more time with their faculty mentors, asked for help often, and had faculty who had much control over their projects, rated their research expertise similarly to their mentors. One possible reason is that those students who have lower perceptions of their abilities were more likely to seek and to accept guidance from their faculty mentors. They, therefore, placed greater value on their mentoring relationship than those students who already felt as if they knew what they were doing, and therefore, were not as willing to accept their mentor's advice. Interestingly, faculty mentors who had high quality relationships with their students rated these students' levels of research expertise higher than the students rated themselves. This implies that although faculty may have had a higher quality relationship with a student, conversations might not have focused primarily upon students' development as researchers. On the other hand, students might have understood more thoroughly the expertise of their faculty mentors and placed them in a position of esteem. As a result, students' comparisons of their research abilities may have been more critical than students who had lower quality relationships with their faculty mentors.

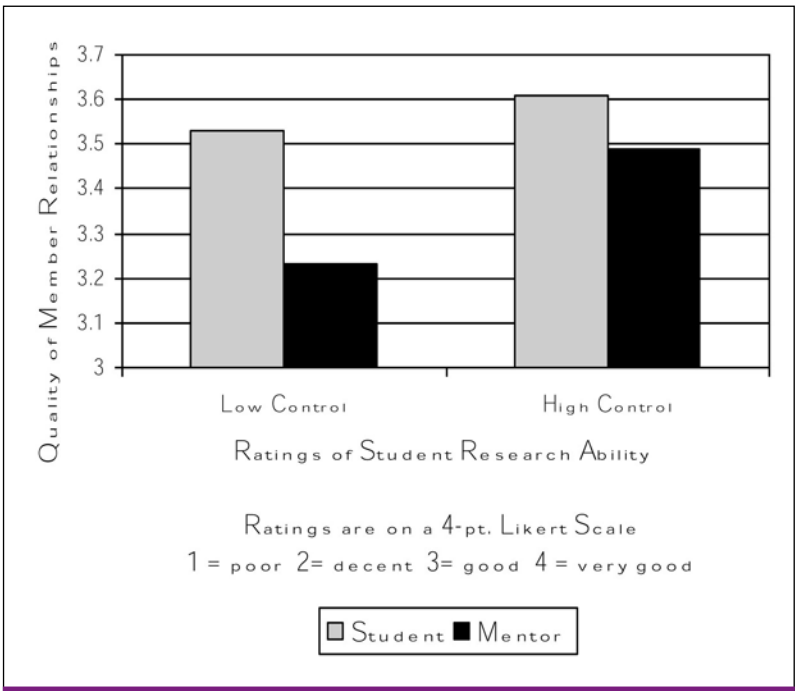

Figure 4. Perception of How Much Control Faculty Had Over Student Compared to the Ratings of Student Research Ability

V. SUGGESTIONS FOR FUTURE WORK

The authors offer several suggestions for expanding the current study. Among these suggestions include the addition of qualitative research methodologies, longitudinal reporting of data, addition of control groups, and an explicit connection of the research to mentoring theories and literature. Additional details about ways to address each of these concerns follow.

A. Addition of Qualitative Research Methodologies

Limitations of Kardash's [8] and the current study include the self-reporting nature of the quantitative surveys and the absence of control groups. This may be remedied via the implementation of qualitative techniques (e.g., one-on-one and focus group interviews) that are used independently of this study or qualitative techniques that are used in conjunction with previous quantitative techniques. Independent qualitative studies may explore how faculty use their time with students to expand students' thinking and understanding of their research [1] or the motivations that graduate and faculty mentors have for spearheading undergraduate student research projects [4]. In addition, a se-

quential explanatory mixed methods design that would use the quantitative analyses presented in the first part of this study to inform the collection and analysis of qualitative analysis might be utilized [11]. Questions that might be asked to faculty mentors and to graduate student mentors based upon the quantitative results found within Tables 1 and 2 include the following:

- What research skills do you expect an undergraduate student to gain as a result of conducting summer research within your laboratory?
- Did (name of undergraduate student within mentor's lab) meet your research expectations? Why or why not?
- (After distributing a quantitative survey about a student's research performance ask,)
- Why did you evaluate (name of undergraduate student)'s research performance as you did?
- How has (name of undergraduate student) changed in his/her research performance since the beginning of the summer?
- Based upon the strengths and weaknesses that you have seen in your student, what advice would you give him/her as he/she continues to develop as a researcher?"

B. Longitudinal Evaluations of Students' Research Experiences and the Use of Control Groups

To understand how students' research stories are developing, a longitudinal study might be conducted. In this way, researchers might note individual differences in students' research experiences and examine these differences based upon variables such as gender, ethnicity, year in college, or discipline. In addition, research highlighting changes in students' acquisition of research skills at different points in time might inform the development of models about undergraduate research trajectories and might highlight connections between undergraduate and graduate students' research experiences.

Similar to the work of Bauer and Bennett [12], control and treatment groups may be created to compare SURF research groups to other research groups. For example, SURF students' experiences may be compared to the experiences of non-SURF students (e.g., students conducting academic-year research for variable course credit or undergraduate students engaged in short term research within one disciplinary area). In addition, SURF faculty and graduate student mentors' experiences may be examined relative to the experiences of non-SURF faculty and graduate student mentors. Research questions of interest might explore how SURF students' and mentors' experiences are similar or different from the experiences of non-SURF research students and mentors or how individual research experiences impact students and mentors.

C. Connection to Theory

A final recommendation is to connect undergraduate research studies to theoretical models across multiple disciples. Building upon the work of the authors [9], researchers might explore mentors' motivations for participation in research. In addition, researchers may use theoretical frameworks to explore topics such as undergraduate researchers' development of research identities [13, 14], selection of careers [14], and subsequent social and academic integration because of their engagement in undergraduate research [16]. From a mentor perspective, studies exploring the relationship between the mentoring of undergraduate researchers and scholarship [15] and the placement of undergraduate research within communities of practice [17] are needed.

VI. CONCLUSIONS

Students tend to rate their own abilities and skills as higher than do their faculty mentors. However, there is greater agreement between students and their graduate student mentors. This indicates that there might be something about the characteristics of the mentoring relationship which can account for some of these differences. Unfortunately, we did not have enough data on graduate student mentors to explore further the differences between faculty mentors and graduate student mentors.

We examined the dynamics of the student-mentor relationship according to four characteristics: quality of the mentoring relationship, mentor and student time spent together, student frequency seeking mentor advice, and the control of the faculty over the research project. We found that the greatest discrepancies between faculty and student ratings existed in situations where the mentoring relationship quality was high, the amount of time spent together was little, the students rarely went to the mentor for advice, and the faculty exerted little control over the student. In all but the first case, students rated themselves higher than faculty rated themselves. This indicates that, although several students overrated their abilities, stu-

dents in whom faculty had least confidence were those students who were most likely to overrate themselves. Alternately, those students who the faculty mentors believed were doing well were likely *underrating* their abilities. Finally, faculty rated those students they saw the least and controlled the least as lower. This is problematic, since these students are the same ones who did not feel they needed faculty help, but actually need that help the most. These students were least likely to seek out their mentors for advice, and their mentors were least likely to spend time with them. These students might be in danger of "falling through the cracks."

Further research on the characteristics of student relationships with their mentors and on differences in these relationships based upon student abilities, is warranted. Details about such studies are proposed within this paper, and authors recommend that researchers consider these suggestions to advance understanding about undergraduate research and mentoring of student researchers in engineering and other disciplines.

Acknowledgements

This work was funded by Purdue University and by the Summer Undergraduate Research Fellowship (SURF) program. The authors wish to acknowledge the following for their contributions to this project: Dr. Jay Gore and Dr. Melba Crawford for their feedback about this project and directions for future research; Ms. Vicki Leavitt and SURF staff for their assistance in the coordination of our research efforts; Dr. Deborah Follman and Mr. Brian McEnany for help in developing pre- and post-program instruments; and the School of Engineering Education for providing resources to assist in the publication of this research project.

Bibliography

[1] E. Seymour, A.B. Hunter, S. Laursen, and T. DeAntoni. Establishing the benefits of research experiences for undergraduates: First findings from a three-year study. *Sci. Educ.* 88, 493–594 (2004).

[2] L. Blockus, C.M. Kardash, M. Blair, and M. Wallace, Undergraduate internship program evaluation: A comprehensive approach at a research university. *Council on Undergraduate Research Quarterly*, 18, 60--63, 91 (1997).

[3] S.J. Fitzsimmons, K. Carlson, L.C. Kerpelman, and D. Stoner, *A Preliminary Evaluation of the Research Experiences of the Research Experiences for Undergraduates (REU) Program of the National Science Foundation,* (Center for Science and Technology Policy Studies), ABT Associates, Washington, DC: (1990).

[4] A.L. Zydney, J.S. Bennett, A. Shahid, and K.W. Bauer, Impact of undergraduate research experience in engineering. *J Eng Educ.* 91, 151–157 (2002).

[5] R.S. Hathaway, B.A. Nagda, and S.R. Gregerman. The relationship of undergraduate research participation to graduate and professional education pursuit: An empirical study. *J. Coll. Student Dev.* 43, 614–631 (2002).

[6] J.F. Kremmer and R.G. Bringle. The effects of an intensive research experience on the careers of talented undergraduates. *Journal of Research and Development in Education,* 24, 1–5 (1990).

[7] B.A. Nagda, S.R. Gregerman, J. Jonides, W. vonHippel, and J.S. Lerner, Undergraduate student faculty research partnerships affect student retention. *Rev. High. Educ.* 22, 55–72 (1998).

[8] C.M. Kardash, Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. *J. Educ. Psychol.* 92, 191–201 (2000).

[9] Authors, Engineering students' motivations for engaging in undergraduate research: Extrinsic or intrinsic? *Journal of Women and Minorities in Science and Engineering.* (In preparation).

[10] SURF Program Website. <https://engineering.purdue.edu/Engr/Research/SURF/>, accessed 5/10/07.

[11] J.W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches,* Sage Publications, Thousand Oaks, CA (2003).

[12] K.W. Bauer, and J.S. Bennett, Alumni perceptions used to assess undergraduate research experience. *J. Higher Educ.* 74, 210–230 (2003).

[14] D.C. Holland and D. Skinner. Prestige and intimacy: The cultural models behind Americans' talk about gender types. pp. 78-111 in D. Holland and N. Quinn (eds.), *Cultural Models in Language and*

Thought. Cambridge: Cambridge University Press: (1987).

[13] S. Stryker. Identity theory and role performance. *J Marriage Fam.* 30, 558-64 (1968).

[14] S. Stryker. Identity theory: Its development, research base, and prospects. *Stud Symbolic Interact.* 16, 9-20 (1994).

[15] E.L. Boyer. *Scholarship Reconsidered: Priorities of the Professoriate*. Jossey-Bass: San Francisco: (1999).

[16] V. Tinto. *Leaving College: Rethinking the Causes and Cures of Student Attrition* (2nd ed.). University of Chicago Press: Chicago (1993).

[17] E. Wegner and J. Lave. *Communities of Practice: Learning, Meaning, and Identity.* Cambridge University Press: New York (1998).

Monica F. Cox, Ph.D., is an Assistant Professor in the Department of Engineering Education at Purdue University. Her research interests include teaching and learning in engineering education; engineering faculty and student development; and assessment and evaluation of engineering curricula, faculty pedagogy, student learning, student retention, and student engagement within engineering courses. She is a recent NSF Faculty Early Career (CAREER) Award Recipient and is the Director of the Pedagogical Evaluation Laboratory Group at Purdue.

Angie Andriot is currently a doctoral student in the Department of Sociology at Purdue University. Her dissertation, entitled "Gender and Engineering Identity Development among Undergraduate Majors," is partially funded by grants from the National Science Foundation and the Purdue Research Foundation. Angie also works part-time doing research for the College of Engineering.