Examining the Skills and Methods of Graduate Student Mentors in an Undergraduate Research Setting

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Abstract

Previous studies have shown that graduate student mentors have great impacts on the education of undergraduate researchers in various science and engineering undergraduate research (UR) settings. The importance of graduate mentors for UR students is highlighted by researchers who claim 1) UR students have more frequent meetings and interactions with their graduate mentors than their faculty advisors and 2) graduate students are often asked by their faculty advisors to be the main points of contact for UR students. The relationship between graduate students and UR students, however, is not without challenges. Among the challenges include graduate students' lack of knowledge in skills and practices in mentoring UR students. Therefore, the purpose of this study is to identify skills and practices that graduate mentors have successfully employed in an UR research setting and that undergraduate students have found to be beneficial.

Undergraduates enrolled in a summer UR program at a large Midwestern university were given an opportunity to nominate their graduate student mentor for the Outstanding Graduate Mentor Award. As part of selecting the awardees, undergraduates were asked to complete a nomination form assessing their mentor's qualities, describing their relationships, and stating why he/she should be recognized as an outstanding graduate student mentor. Twenty-two nomination forms were submitted and qualitatively analyzed for this study. The results determined skills and practices employed by graduate mentors, including introducing information systematically, explaining and discussing contents multiple times, attending weekly meetings, preparing detailed instruction manuals, and helping undergraduates find their own answers to their questions. These practices were highly appreciated by undergraduate students in the UR program.

Introduction and Background

A body of literature has shown the benefits of undergraduate research (UR) programs for undergraduate students[1-4] and graduate schools in the U.S.[2,5] The benefits from UR experiences include undergraduates' increased abilities to conduct research,[6] to communicate effectively,[1] to learn and work like a researcher,[2] and to take greater responsibility for their work.[2] As a result, students have reported higher satisfaction with their baccalaureate experiences.[3] These student gains are also true for minorities and women in STEM disciplines.[7-9] As for the gains from UR programs with respect to graduate schools, undergraduates who completed UR experiences have a clearer understanding and expectation of graduate programs[2] and are more likely to continue their education into graduate school, hence increasing graduate school enrollment in the U.S.[1,5,10]

Given the importance of UR programs, identifying aspects of UR experiences that could optimize UR experiences for undergraduates is crucial. Professional organizations have proposed mentoring as one of the most important aspects of an UR experience. For example, the Association of American Colleges and Universities suggest that the two important factors for the success of UR experience are the roles of a mentor and the quality of the mentoring relationship.[11] Researchers further show that mentoring is one of the most important factors for

creating satisfying UR experiences from undergraduates' perspectives.[12-14] Indeed, research shows that a positive mentoring experience fosters greater understanding of a research topic, personal and professional growth, and acquisition of various skills for future careers.[13]

Many of the UR program models across the U.S. have stated that a student's primary mentor is a faculty member.[15-17] They have suggested that UR students work side-by-side with a faculty member who generally initiates the project. However, a large body of literature suggests that many undergraduates frequently work with graduate students or post-doctoral fellows, and in fact, it is these students/fellows who are responsible for mentoring undergraduates (i.e., supervising and advising) in UR settings.[18-21] For example, in a recent qualitative study at two research-extensive institutions, researchers[22] identified that over 60% of undergraduate researchers were mentored by graduates or post-doctoral fellows. Furthermore, other researchers[18] identified that many undergraduates in large research institutions are mentored by graduate students because of faculty's lack of time and multiple positions and responsibilities in academia.

Given that much of the responsibility of mentoring UR students is passed on to graduate students or post-doctoral fellows, they have a great impact on the education of undergraduate researchers in UR settings.[12] Accordingly, there is a need for research that identifies the roles, skills, and practices that graduate mentors must exhibit as a primary mentor in UR settings. However, there exists limited research in this area.[22] Of the few studies that have explored graduate student mentoring in UR settings, much of the investigations have examined mentor-mentee relationships, the influences that undergraduates and graduates have on each other,[23,24] or motives, gains, and challenges from the graduate students' perspectives.[24] These studies did not explore how graduate mentors work and collaborate with UR students over the course of UR experiences/programs; therefore they did not identify effective ways to train undergraduates. Given the limited understanding of the skills and practices of graduate mentors that could support undergraduate researchers' learning in their research settings, further study is needed to enhance undergraduates' experience in UR settings.

This study, therefore, aims to identify explicitly the mentoring skills and practices of graduate mentors in a summer UR program by analyzing the responses of twenty-two students majoring in engineering and science. Furthermore, this study examines how graduate mentors fulfill mentoring roles such as initiating and maintaining regular contact with their mentees; providing advice, guidance, expertise, and support to their mentees; and defining clear goals and expectations for their mentees. Identifying effective mentoring practices that help undergraduates with their research will add to the current existing literature while helping graduate mentors in UR settings.

Methods

The purpose of this qualitative research study is to identify the practices and skills that 1) graduate mentors have employed successfully in UR settings and 2) undergraduate students have found to be beneficial. Nomination forms completed by UR students, were analyzed to investigate the strategies, techniques, and/or practices that graduate mentors have practiced to facilitate UR student success.

Data Collection

The 150 undergraduates (70% male and 30% female) participating in a 2012 summer UR program at a large Midwestern research intensive university were given an opportunity to nominate their graduate student mentors for an outstanding mentor award. The award, given by the UR program, was to recognize graduate student mentors who have provided exceptional guidance and instruction to UR students during the summer research program. To nominate their mentor for an award, students in the UR program completed a nomination form. The form consisted of a two-page document that asked students to assess, based on their experience with the mentor during the summer, their graduate student mentor's technical and instructional competence, supervision and guidance, passion and enthusiasm for research, and motivation. The second part of the form asked students to describe, in less than 500 words, their relationship with their mentor and why they felt their mentor should be recognized as an outstanding mentor. Finally, the nomination form asked for three demographic questions: 1) whether the student's mentor was a graduate student or a post-doctoral fellow, 2) the length of time that the student had known the mentor, and 3) the approximate number of hours per week that the student received guidance from his/her mentor.

The nomination forms for best graduate mentor award analyzed in this study can be categorized as a data collected from non-human sources,[25] which are "sources at least at one remove from a human being" (Lincoln & Guba, 1985, p. 287),[25] such as documents and records. According to Lincoln and Guba (1985),[25] and as it applies to this study, there are number of advantages to using the nomination forms as a source of information. First, they accurately provide accounts and examples of mentoring skills and practices that occurred at the summer UR setting. Second, they are rich sources of information appearing in the natural language of undergraduates and contextually relevant and grounded in the UR context. Third, they are "legally unassailable" (Lincoln & Guba, 1985, p. 277),[25] that is, statements documented in these forms by the undergraduates are legally accountable. Finally, they are available and free. These advantages make these forms valuable sources of information to understand the skills and practices that undergraduates have found useful.

Participants

The twenty-two UR student participants in this study, representing eight majors (Table 1), completed the form to nominate their graduate mentor for the 2012 Outstanding Graduate Mentor award. The nominators' and nominees' profiles are displayed in Table 1. All but two mentors were graduate students pursuing higher degrees at this university; the other two mentors were post-doctoral fellows. The gender distribution for nominees was 17 males and 4 females. One student (Student 21) had more than one graduate student mentor. The majority of UR students met their mentors for the first time in the summer research program or just prior to the beginning of the program, and hence identified the period that they had known their mentor to be three to four months. There were some undergraduates who knew their mentor prior to the program from prior lab meetings or from non-academic related organizations.

Table 1. Engineering and science undergraduate research students who nominated their mentor and their mentor's profiles

Student	Student major	Student's	Mentor's	Mentor's	No. of

ID		gender	position	gender	Months known
1	Computer & Information Science	Male	Graduate student	Male	3
2	Electrical Engineering	Male	Graduate student	Male	3
3	Mechanical Engineering	Male	Graduate student	Male	3
4	Mechanical Engineering	Male	Graduate student	Male	4
5	Electrical Engineering	Female	Post-Doctoral	Female	3
6	Civil Engineering	Male	Graduate student	Female	12
7	Civil Engineering	Male	Graduate student	Male	3
8	Mechanical Engineering	Male	Graduate student	Female	4
9	Mechanical Engineering	Male	Graduate student	Male	12
10	Biomedical Engineering	Female	Post-Doctoral	Male	3
11	Industrial Engineering	Male	Graduate student	Male	4
12	Computer Engineering	Female	Graduate student	Male	3
13	Mechanical Engineering	Male	Graduate student	Male	3
14	Mechanical Engineering	Male	Graduate student	Male	6
15	Biomedical Engineering	Male	Graduate student	Male	7
16	Aerospace Engineering	Male	Graduate student	Male	3
17	Aerospace Engineering	Male	Graduate student	Male	3
18	Mechanical Engineering	Male	Graduate student	Male	3
19	Civil Engineering	Female	Graduate student	Female	3
20	Mechanical Engineering	Male	Graduate student	Male	3
21	Agriculture Science	Female	Graduate students	Unknown	3
22	Mechanical Engineering	Male	Graduate student	Male	12

Data Analysis

The constant comparative method, as recommended by Lincoln and Guba (1985),[25] was used to analyze the documents. First, all twenty-two documents were read twice. Second, all documents were read again, but this time the first author made memos about what stood out in the documents and possible ways to interpret what the undergraduates stated in their documents. The process involved reading a paragraph as well as each sentence to ensure the details of the data were captured. Third, each document was coded such that incidents from the document were assigned to a code. The resulting codes were concepts that were larger than the data themselves and were able to "hold" more than one instance of data. Each time new instances appeared throughout the document, a decision was made as to whether the new instance belonged to an existing code or constituted a new code. The process involved comparing incidents with other incidents already included in the code. The judgment used to decide whether to place an incident with another incident into a code was done through a "look-alikeness" or "feel-alikeness" (as recommended by Lincoln and Guba, 1985, p. 342).[25] While coding through the incidents, there were two types of codes: those that emerged from the nomination forms (exploratory) and those that were constructed (descriptive). Throughout these steps, memos were kept capturing ideas and thoughts that came throughout the coding process. Questions such as "What is going on here?, How do the undergraduates define the situation?, What have the mentors done?, and How

does what they stated match with what I see?" were continuously asked. These questions helped to define the codes as well as differences among codes.

The next step of the analysis involved grouping the codes (i.e., forming a category) according to their salient properties. With the tentatively identified category properties, the constituting codes belonging to its assigned categories were checked. The process ensured the incidents began to converge into stable and meaningful categories. The definition and property of each category began to take their forms through comparison and integration. It was evident that the categories became more coherent, that is, each category showed variation according to its properties and dimensions. The final process involved ensuring that each category was defined and was supported by data.

Results

The nomination forms yielded lists of actions and mentoring practices utilized by graduate student mentors in the UR setting. Five actions/practices are identified: 1) assisting undergraduates to comprehend their research project, 2) helping undergraduates with their research work/process, 3) answering undergraduates' research related questions, 4) advising undergraduates to communicate their research findings, and 5) other mentoring practices (or activities) highly appreciated by undergraduates.

Assisting undergraduates to comprehend their research project

One of the earlier tasks graduate mentors were responsible for was to inform UR students of their summer research projects and to provide necessary background information for them to begin these projects. For example, background literature, purpose of the research, and decisions that had to be made all needed to be communicated to undergraduates to begin the research as soon as possible. For this reason, many mentors provided these types of information via email prior to the start of the program or in the first couple of weeks of the program. A Mechanical Engineering student wrote:

> *"After I was selected for the [summer UR] program, I was very excited and nervous about the project. I was not confident with my knowledge in hydraulic systems. However, I immediately got a congratulatory email from my mentor. That email also had some of the main topics he thought I should look into in my spare time. Furthermore, he provided me with resources to read about those topics, to ensure ease into the summer research."* (Student 3)

In addition to providing information for undergraduates to read, graduate mentors ensured that undergraduates understood these materials by discussing the literature, by giving appropriate follow-up tasks, by asking the undergraduates questions to check their understanding, and by helping them become familiar with the project. To enable undergraduates to recognize their research space and comprehend their project, graduate mentors:

1. Used existing literature (papers, articles, and books) to convey information about the student's project and to alleviate students' doubts, limitations, problems, and gaps in the research area.

2. Introduced information systematically and concisely (but with enough details) at the level of knowledge for undergraduates to comprehend with the goal of showing students what had been done and what needed to be done.
3. Explained and discussed background knowledge multiple times to help students understand the complex issues and disciplinary fundamentals necessary to solve problems.
4. Played devil's advocate, that is, pretended to be against student's ideas or plans in order to make the student discuss it in more details.
5. Created and gave appropriate levels of assignments (or tasks) to be solely completed by undergraduates to help them understand certain theory behind the research. Some tasks included operating lab equipment, which made research, according to undergraduates, "interesting".

Helping undergraduates with their research work/process

Another major task many of the mentors were responsible for was helping their mentees with their research process, planning, and work. It was evident from the nomination forms that mentors (1) devoted their time to developing and providing a summer research plan, (2) met with students on a regular basis, and (3) helped with the development of student research skills. All of these efforts were not only appreciated by the undergraduates, but also helped them make progress and clarify what needed to be accomplished on a daily, weekly, and monthly basis. To help students with their research work and process, mentors:

1. Thought through the details (tasks, goals, and time period) to develop and provide a comprehensive summer research plan (or schedule) for undergraduates. Some mentors went into great depth that covered details from design phase of an experiment to writing the final report.
2. Worked side-by-side on a daily basis with undergraduates to discuss their progress, issues and approaches, especially in the early phase of the summer program. In the case when the mentor had to go out of town, they used internet video conference calls to check on the student's progress. Both of these cases were evident from a female and a male Electrical Engineering UR student, respectively, as shown below.

   "The first week of [the summer UR program], she sacrificed the comforts of her office by moving into a larger room where she and I could work side-by-side daily. I appreciate her organizational skills and planning methods so much. There was rarely a day where I was left completely unsure of which direction to take in my research." (Student 5)

   "Due to his research projects, he had to go to Berlin, Germany, for a couple of weeks, but before that, he thought through every single detail to make sure I would not have a delay with my progress . He made a schedule for Skype meetings to review my progress…" (Student 2)

3. Attended the weekly meetings between the student and the faculty member to discuss the student's progress. In these meetings, mentors maintained logs from prior discussions and wrote plans for what needed to be accomplished in the future.
4. Prepared detailed instruction manuals on how to operate lab equipment and walked through the procedure multiple times, giving students' ample amount of time to sequentially

categorize tasks as they needed to be done. This process helped undergraduates check their own steps when working in a lab, as evident from a Mechanical Engineering UR student's testimony.

> *"In addition, when I first starting working in the lab, he provided me with extremely well-detailed instructions for how to use the equipment, so that I could easily check my steps when working in the lab."* (Student 13)

> *"The first day, he had already prepared instructions on how to use the Carver press to make pellets in the lab. He walked me through the procedure a couple times, and by the end of the day, I easily was able to press sample pellets for him. The next day, he had provided the procedure for using the high energy ball mill. Once again, he walked me through the steps, and if I had any concerns or was stuck through any step, he'd kindly answer my calls to clear any confusion that I would have had."* (Student 13)

5. Identified what students did well, provided constructive criticism, and began to outline the next steps. A male UR student from Mechanical Engineering stated:

> *"When discussing a test result or another activity, he quickly points out the best aspects of my work and smoothly transitions into constructive criticism and subsequently begins formulating the next tasks."* (Student 22)

Answering undergraduates' research related questions

One of the most common tasks that many mentors engaged in was answering students' research-related questions. According to the nomination forms, questions ranged from designing an experiment to analyzing experimental results. To answer these questions, various methods were utilized by mentors. Many undergraduates appreciated graduate mentors' efforts to guide them in finding answers on their own instead of giving the answers. Students also appreciated mentors' patience and effort to explain things clearly and comprehensively. To answer students' research related questions, mentors:

1. Asked undergraduates to describe the phenomena and explain what was happening. Graduate mentors then provided ways to think more critically and considerately about the problem. For example, mentors gave students the knowledge to understand the problem and allowed students to think upon and reflect about a problem rather than giving a solution.
2. Asked students to investigate answers by searching through primary or secondary data sources. For example, graduate mentors pointed to the people with the expertise or to the literature to guide students to find their own answers. While doing so, mentors taught students not to expect to learn knowledge easily from them. This was evident from the following statement:

> *"He usually does not tell the answer directly because he wants me to think of the possible reasons firstly. Also, sometimes he asks me several difficult phenomena happening on the real engine and asks if I could explain them."* (Student 9)

> *"As a graduate mentor, the most important thing he taught me is that not to expect learn knowledge easily from him. He explained it in this way, if I think he can teach me, and then who can teach him?"* (Student 9)

3. Gave detailed explanations with support from mathematical and/or engineering analysis to answer students' questions, rather than a brief or easy answer.
4. Checked each step completed by undergraduates and helped them identify errors and/or misconceptions. While doing so, mentors provided suggestions to tackle the problem and/or opportunities to troubleshoot the issues on their own. As one student from Industrial Engineering stated:

> *"He is always willing to take the time to help me with issues I have, and not just to tell me the answers but to walk me through the solution and allow me to do it myself."* (Student 11)

Advising undergraduates to communicate their research findings

Another area where mentors played a key role in the UR research program was helping undergraduates develop communication skills. With the summer research program requiring students to present either a poster or an oral presentation and submit an abstract and a final report, many undergraduates relied on their mentors for insight and feedback on communicating their research work. As evident from the data, students practiced their presentation in front of their mentor and gave a draft abstract/paper to mentors for review and feedback. To help students communicate their research, mentors:

1. Commented on the content and transitions of the oral presentation slides during lab meetings
2. Asked students to practice their presentations in front of the research group
3. Taught engineering jargon to help students describe certain phenomena in their presentations and writings
4. Requested that students properly and formerly present every result when discussing experimental research

Several of the methods stated above are well summarized by a UR student:

> *"On the other hand he also assisted me in improving my presentation skills. During the 2-3 presentations at the lab, He has been a true devil's advocate in judging my presentations by commenting on the big things like content to small things like transition and fonts. He has ensured that I prevent some of the past mistakes he has made during his presentations in seminars."* (Student 3)

Other mentoring practices appreciated by undergraduates

During the research program, graduate mentors performed various practices that were highly appreciated by undergraduates. These practices encouraged undergraduates to ask questions, motivated undergraduates to continue with their research during difficult times, placed responsibility on the undergraduates for their own research progress, and helped undergraduates to work collaboratively with other graduate and undergraduate students in the lab. Furthermore, these practices developed relationships that went beyond mentor-mentee, but became

"friendship" according to undergraduates. Examples of mentors' practices that undergraduates valued highly included:

1. Mentors respected undergraduates' thoughts, advice, and questions related to research. For example, decisions were never made without students' own input on all aspects of research, including the most complex decisions. Sometimes plans were changed based on the suggestions given by the undergraduates. Naïve questions or complaints were never turned away but were highly encouraged and valued. In addition, undergraduates' intellect was never questioned. The respect shared between the mentors and the students allowed undergraduates to ask questions without being judged.
2. Mentors shared their own research and past research experiences with their undergraduates. Mentors regularly discussed their own experiments in their theses or dissertations along with reasons why certain instruments were used over others or why certain decisions were made in their work. Sometimes mentors demonstrated their work and even allowed students to participate in the experiment by asking them to collect data. In addition, mentors shared their own stories of research failures to encourage students to be persistent with their own research. These were evident from the excerpts provided by two female UR students in Biomedical and Civil Engineering, respectively.

   "I was taking images on a microscope determining how many cells were alive versus dead. All was going well until something started to go wrong. All the cells were showing up as dead as I continued imaging. I called over to him for guidance and while expressing my disappointment he took time to try to help me understand that it was okay for this to happen. He said experiments have to fail several times in order for us to learn and for them to be perfected. Failure is to be expected during research. He took me over to his desk and showed me a whole box of chips he had made. He explained that every single one in the box was a failure, but that there has to be many failures to get a real success." (Student 10)

   "She also taught me a lot of things that are done on the lab floor. For example, she would tell me what was going on in her experiment or why a certain kind of instrument was being used, etc. I was able to learn not just about our project, but other projects as well." (Student 19)

3. Mentors were always available to meet and discuss with undergraduates. Students appreciated that mentors took the time to work through their concerns, such as questions related to theory or lab equipment or the various stages of research, no matter how busy the mentors were. Mentors were prompt with their responses, whether this was face-to-face or via email. Also they promptly guided undergraduates to the right path and gave suggestions that would be beneficial to undergraduates throughout the project. As one student wrote:

   "Also, whenever I needed her guidance she always stopped what she was doing and directed me. Although she has many projects to attend to and several other responsibilities she gave me priority and was always prompt in her support." (Student 5)

4. Mentors learned, explored, developed, and discovered together with their undergraduate mentees. One student stated in the nomination form that during the UR research phase, there were times when both he and his mentor had to acquire new knowledge and complete a new experiment setup to conduct the research. In this instance, the mentor and the mentee spent weeks together to learn new skills and knowledge and apply them to the project. The student stated that he enjoyed working together with his mentor and saw firsthand the mentor's passion and enthusiasm for learning new material.
5. Mentors gave space and time for an undergraduate to independently explore and experiment. For example, mentors helped with the first few tests, and then undergraduates had enough freedom to explore the equipment by themselves. Mentors kept an eye out for dangerous procedures but did micromanage them. Mentors balanced between giving directions to students and allowing students to take their own paths when solving the challenges inherit to performing research. As a female UR student from Computer Engineering wrote:

   "*He gave me space and a platform to learn and explore various methods to work through my project while also providing me with his invaluable input*." (Student 12)

   Similarly, a male UR student from Computer and Information Science wrote:

   "He has been very supportive about my work and always gave me my own space to think about things as to how do I want to do them. I feel the most important thing for any intern is that mentor should have faith in the intern's capability and should also give him independence to work on his own. I feel I was lucky enough to get it. I was never pressured about anything." (Student 1)

6. Mentors regularly visited undergraduates to check on the UR students' progress. This was especially true when undergraduates did not ask questions for awhile. Pausing from their own work, mentors came over to check whether there were any questions or concerns, and if there were any, they provided suggestions to overcome those challenges. They also reminded students of the deadlines and advised to strategize accordingly.

   "He is almost always in the lab when I am and is very mentally present and aware of things I need. Even if I don't ask him a specific question for a while he will pause from his work to come make sure my things are going well." (Student 11)

7. Mentors spent time with the students outside the research program to discuss future career options and to participate in non-research related activities. For example, mentors invited students to lunch on a weekly basis (sometimes with other people in the lab), and during this break, their discussion included life of a graduate student, the current status of the industry, how to effectively network, and tips to excel academically to prepare for future career. As male UR students from Biomedical Engineering and Computer and Information Science wrote:

"He has not only been a role model in how to conduct research, but he is always open to questions about my future career plans. He has helped me identify my options both professionally and academically. He has provided me tips in order to excel in my undergrad academic career in addition to research." (Student 15)

"…go out for lunch once a week. My mentor also inquired about my future advice and also gave me valuable advice in terms of my interests and graduate school. He gave me very specific information about different possibilities that I had from here." (Student 1)

The data also showed occasions when mentors and mentees just had fun. For example, graduate mentors invited students to trivia nights with other graduate students and participated in curricular activities with the department team, such as playing soccer, tennis, or softball games. A UR student wrote:

"…extra things to make me feel welcome, such as playing with me in the [summer UR program] soccer league, grabbing lunch or coffee every once in a while, or even playing a round of tennis after work hours." (Student 11)

The attributes exhibited by the mentors and time spent outside the research setting with the mentee not only made undergraduates feel valued in the lab but helped to develop a strong personal relationship with the students, with some students calling their mentor "friend" as illustrated below.

"My relationship with my mentor has more of been as a friend rather than a mentor." (Student 1)

"In many aspects he has gone beyond the student-mentor relationship." (Student 2)

"I have loved working with her all summer. I'm very thankful for such a great mentor. There is no doubt in my mind that our relationship will continue in the future." (Student 5)

"My mentor has not only been a great mentor to me but also a great friend. It's a wonderful experience being able to work directly with graduate students in the lab and be so welcomed into the research." (Student 11)

Discussion

The qualitative analysis of the nomination forms used to nominate outstanding graduate mentors has shown important attributes of graduate mentors in an UR program. Graduate mentors educated, encouraged, and guided students with their research work, fostered professional development and independent learning, and attended to the needs of the students. At the same time, graduate mentors were patient, accepting, and prone to disclosing their thoughts and

sharing research responsibilities. All of these attributes resonate closely with previous findings on mentoring by faculty in engineering and science[18,19] and other disciplines.[26,27]

This study further adds value to the existing literature by identifying specific mentoring practices and skills used by graduate student mentors within engineering and science UR settings. Specifically, effective graduate mentors' skills and practices help students to get acquainted quickly with the research knowledge; to provide support for research process and work; to answer questions and passing of knowledge; and to help students communicate their research findings. In addition, various practices that result in positive mentor-mentee relationships have been determined. Taken together, these results reveal key skill sets for high quality mentorship that can be applied by current and future graduate mentors.

Furthermore, the results from this study can be used in workshops to educate and prepare graduate students for mentoring in engineering and science UR programs. For example, during these workshops, case studies or short videos of mentoring scenarios in UR settings could be shared with graduate mentors. These scenarios could include scenes representing the five actions/practices identified in the paper. Participants can be asked to situate themselves in a similar situation and describe how they would react and what they would do to effectively attend UR students' need as part of a workshop activity. Participants could answer the questions using the summarized mentoring techniques or think of their own mentoring techniques by building on the finding discussed in this paper. Various solutions generated by participants will allow the workshop facilitator to lead discussions, ask participants to share potential solutions, and promote learning among participants.

The limitations of this study should be noted. This study only explored the views of UR students who completed the nomination forms. Therefore, future investigation of the views of graduate mentors on mentoring skills, as well as ineffective mentoring skills identified by undergraduate students, will add value to this study and enhance our understanding of effective mentoring skills.

Conclusion

Graduate students are frequently called upon to mentor UR students. However, many graduate mentors are unaware of how to effectively train and work with UR students. Therefore, this study identified the skills and practices that graduate mentors have successfully used in an UR setting. This study analyzed twenty-two nomination forms submitted by UR students to nominate their mentor for the graduate mentor of the summer award. The results showed numerous mentoring skills and practices that graduate students have employed. For example, introducing information systematically, explaining and discussing relevant content multiple times, attending weekly meetings, and being accessible to students helped UR students with their research work. In addition, the study highlighted important attributes exhibited by graduate mentors in UR setting, such as being patient, encouraging, respecting students' thoughts, advice, and questions, and willing to share ideas and research responsibilities. The findings from this study have the potential to show graduate students how to successfully mentor undergraduate students in UR settings.

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