



Am I a Boss or a Coach? Graduate Students Mentoring Undergraduates in Research

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Abstract

YOU'RE@CU is a mentoring program in which graduate students are paired with 1st or 2nd year undergraduate engineering students to conduct research is now entering its third year of operation at The University of Colorado Boulder. The undergraduate mentees benefit from exposure to a research community and the process of doing cutting-edge engineering research, while the graduate student mentors benefit from the experience of being a mentor, defining a project and guiding a novice engineer through the ups and downs of doing research. During their participation in the mentoring program, undergraduates are assessed via pre- and post- surveys to gauge several dimensions of their engineering identity and confidence. Additionally, undergraduates respond to biweekly reflective questions to give researchers a qualitative flavor of their experiences in the mentoring program. Graduate mentors similarly respond to several reflective questions about their experiences during their participation in the program and complete pre- and post- assessments.

This paper presents the qualitative data collected from graduate student mentors during the first two years of program implementation. Graduate student responses have been examined in the context of each individual mentoring partnership to understand the impact of certain mentor training and individual mentor characteristics in establishing fruitful mentoring relationships. Initial findings indicate two salient mentoring models that describe how graduate students actively mentor undergraduate researchers: supervision vs. coaching. In the supervisory model, the graduate mentor sets up a hierarchical boss/subordinate relationship with their undergraduate mentee, while in the coaching model the graduate mentor and undergraduate mentee work together in collaborative partnership. Mentoring program directors and mentors at large can benefit from the experiences of these graduate mentors, as researchers look to develop better training materials and improve program structures to increase the likelihood of positive research experiences for future program participants.

Introduction

Engineering colleges and universities are embracing mentoring programs as one strategy to improve retention and persistence of their diverse undergraduate populations.¹ A one-on-one mentoring relationship provides individualized support for mentees, and a sense that a real person actually cares about the mentee's progress and development within their chosen engineering degree track. The connection between having a caring mentor and undergraduate persistence in engineering was initially described in Seymour and Hewitt's 1997 study *Talking About Leaving*, as the 'unsupportive culture' of math, science, and engineering was one of the primary reasons undergraduates chose to leave majors in STEM fields.² The premise that providing support through mentorship will help undergraduates is one of the primary factors motivating the creation of mentoring programs targeted at young undergraduate engineering students.

A wide variety of mentoring programs exists in both academic and private institutions to serve the purpose of supporting students as they navigate the pathway of becoming an engineer.¹ Some

programs are primarily social in that mentors are responsible for meeting over coffee or meals with their mentees to discuss how school and life in general are going.³ Other programs are focused around specific majors or coursework within a university, with several mentoring programs offering secure (online) spaces for students to ask questions, share and comment on anecdotes from their lives.⁴⁻⁵ A fraction of mentoring programs are intended only for women and underrepresented minorities, while various programs are open to participants of all demographics. Previous papers by the authors examine and summarize mentoring programs in engineering in greater depth than the cursory overview provided here.⁶⁻⁸

This paper explains how a research-based mentoring program for undergraduates at the University of Colorado Boulder has been administered over the last two years, and how experiences from the first two years influence the structure and mentor training for the third year of program implementation. Models of mentoring from the literature are introduced and compared to salient mentoring models that emerged based on data collected from the first two years of program implementation. These proposed mentoring models, termed by the research team as *coaching* and *supervisory* models, are explained in detail and illustrated using the words and experiences of past participating graduate mentors. Specifically, we examine the following research questions:

- 1) How were the supervisory and coaching models of mentoring enacted by mentor and mentee pairs in Spring 2012?
- 2) In what ways did the presence or absence of mentor training affect the model of mentoring employed in each mentoring pair?
- 3) In what ways did mentor and mentee gender affect the development and mode (supervisory vs. coaching) of the mentoring relationship?

Implications of the two emerging models of *research mentoring* are discussed both in the local context of administering the mentoring program and in the broader context of mentoring programs overall and other types of research-focused mentoring relationships.

Background

YOU'RE@CU Program Details

The YOU'RE@CU mentoring program has three main goals: (1) increase retention of undergraduate students in engineering with particular focus on women and underrepresented minorities, (2) expose students to engineering research careers in academia and industry, (3) encourage graduate students to develop mentoring skills through a hands-on mentoring experience.

YOU'RE@CU, now entering its third year of operation at the University of Colorado Boulder, pairs graduate students with 1st or 2nd year undergraduate engineering students to conduct research. The undergraduate mentees, or novices, benefit from exposure to a research community and the process of doing real cutting-edge engineering research, while the graduate student mentors benefit from the experience of being a mentor, defining a project and guiding a novice engineer through the ups and downs of doing research.

Participating undergraduates enroll in a one-credit course which includes a weekly seminar on the fundamentals of research, like keeping a lab book and developing a hypothesis, as well as

presentations by multiple panels of graduate students and industry representatives to offer a extensive taste of the opportunities available to do engineering research following graduation. Undergraduates are expected to work in the research lab under the direction of their graduate mentor several hours a week, and must develop and present a poster explaining their research during a celebratory poster session at the close of the semester and culmination of the program.

Graduate students do not receive formal course credit for participating in YOU'RE@CU, though they do benefit from the experience of mentoring a young undergraduate student in the research process. Mentors are given opportunities for training though sessions offered before the start of the spring semester and program kickoff, as well as “lunch-and-learn” type social gatherings with other mentors during the duration of the program.

During the first year of the program's implementation, graduate student mentors were solicited primarily by asking faculty members to nominate graduate students for the program, resulting in 9 graduate mentor participants. In the second year, graduate students were recruited directly via targeted emails from the program directors and graduate advisors, flyers posted in engineering buildings, and word of mouth from past mentors, program directors and administrators, resulting in 13 graduate mentor participants. As the program continues to grow and mature, both the recruitment and training aspects of the mentoring program will be adjusted and improved to enable scalable expansion.

Initial Graduate Perceptions of Mentoring

In 2011, during the first year of program implementation, the focus was on recruitment of undergraduate mentees and graduate mentors with little thought on the programmatic scaffolding required to enable a successful mentoring partnership over the course of one semester. No official mentoring training or guidelines were provided for the graduate student mentors, and no explicit program expectations or requirements were issued for the graduate students to base their mentoring activities on. As a result, the relationships were established based on the natural inclinations of the mentors and mentees, not on any official recommendations or suggestions. While the mentors were generally positive and optimistic program participants, differences in initial assumptions or assumed understanding of program expectations led to varied interpretations of their self-efficacy as mentors. Early on, several mentors explained their perspectives on the difficulties of being a mentor without a clearly established structure:

“Since she [my mentee] can only work on my primary project, she's just been reading papers that are way over her head and helping me order stuff. The phase my project has been in is not hands-on. This lack of flexibility has also made meeting with her a drain on my time...When structured well, undergraduate help can actually save grad students time.” – Lucy, 2nd year doctoral candidate

“We chat every day that she [my mentee] comes in to lab, she is picking up on things quickly and seems to understand the overall scope of her part of the project...She is a really nice girl and very enthusiastic but I don't think the technical competence is there...To do something meaningful in our lab, more of a time investment is required on some weeks...I think 10 hours/week would be manageable if they budget their time correctly and see working in the lab as one

of their priorities or requirements...I think having the student work more hours would be a better use of my time than doing half of the experiments for them” – Susie, 4th year doctoral candidate

“I feel like I need to stop working and be with her for the whole time she [my mentee] is working (although, she’s beginning to get more self-sufficient)....this time commitment is manageable for me, especially because I think we’re getting some good results” – Evan, 4th year doctoral candidate

“I think that undergraduates can easily put in 10+ hours a week in our lab (many do!), so this is not unreasonable. Because much of the work is self-driven and can be handled by undergraduates, this amount of time would not be taxing on me personally.” – Chris, 5th year doctoral candidate

As seen by this sample of responses, the graduate mentors tended to focus on the output of their undergraduate mentee’s work as evidence of mentoring success and efficacy in the absence of any instruction or criteria from the program administrators. The mentees in the program’s first year were mostly seen as laborers who could help graduate students save time (Lucy), used up too much of the graduate students’ time (Susie), provided good results in exchange for a manageable time commitment (Evan), or could spend more time doing self-driven work without taxing the mentor personally (Chris). The general importance placed on producing results mirrors the outcome-oriented environment of engineering research departments at this large tier-one public university and many others, though is generally incongruent with program goals of increasing retention of undergraduate students in engineering and exposing undergraduates to engineering research careers in academia and industry.

Influence of Mentee Focused Training

In the program’s second year (2012), the program directors chose to implement a mentee-focused mentor training seminar for graduate mentors in the hopes of setting up each mentoring relationship and research project for success. Mentor training materials were adapted from sources including the book *Entering Mentoring* and other on-campus initiatives related to mentoring students in the sciences.⁹ The training session emphasized the difference between a teacher and a mentor, such as being approachable and available as a mentor, and the importance of being individually genuine in establishing a mentoring relationship. No single formula was given for good mentoring; instead mentors were encouraged to take advantage of their personal strengths and interests in establishing a caring and nurturing mentoring relationship. Most importantly, perhaps, graduate mentors were encouraged to view their efficacy as mentors through the lens of the undergraduate mentee’s experience instead of the production of results or outcomes to further their research project. By shifting the focus away from achievement of research goals towards the undergraduate’s perceptions of and experiences in doing research, the program directors hoped to improve the experience for all program participants, both mentors and mentees. Mentor training also provided clear expectations for participating mentors, including a checklist for mentors with items such as “define a research project with milestones and final goals,” “have a discussion with your mentee about his/her educational goals,” “review timeline of your mentee’s research project,” etc.

Proposed Models of Research Mentoring: Supervisory vs. Coaching

In analyzing the data collected from the 2012 undergraduate and graduate mentoring pairs, two salient mentoring models began to emerge from the experiences of the participants: *supervision* vs. *coaching*. While a previous paper by the authors utilized a person-centered case study approach to propose and follow two distinct examples of the supervisory model and the coaching model⁷, the focus of this paper is to introduce the *research mentoring* models and examine how they were exhibited in different ways across multiple different mentoring partnerships and how they can be useful in understanding research-based mentoring relationships overall. Particular attention is paid to the presence or absence of gender affects contributing to the coaching and supervisory models of mentoring, as both same-sex and mixed-sex mentoring pairs are examined.

Supervisory Model

Characterized by a focus on producing results and making research progress, in the supervisory model of mentoring the graduate mentor is primarily a supervisor of the undergraduate's work. The supervising mentor establishes a hierarchical relationship in which the undergraduate mentee is expected to work independently to complete tasks to the supervisor's satisfaction, analogous to a boss/subordinate type relationship in industry. In the supervisory model, the research project is not shared between mentor and mentee; instead the project is the mentee's own and they are on their own to realize success or failure. The supervising mentor expects the mentee to 'look up' to the mentor as a source of expertise and guidance. See Table 1 for summary details.

Coaching Model

In the coaching model, the graduate mentor is positioned as a supporter and helper to achieve collaborative research goals with the mentee. The research project is shared between the graduate mentor and the mentee, and both successes and failures are shared between both members of the mentoring partnership. Instead of a hierarchy in which the mentee looks up to the mentor, both mentee and mentor exhibit feelings of mutual trust and a desire to reciprocate effort for one another. The overall focus of a mentoring partnership under the coaching model is providing a positive research experience for the undergraduate mentee, not producing results or making research progress. See Table 1 for summary details.

Table 1: Comparison of Supervisory and Coaching Models of Research Mentoring

Supervisory	Coaching
Focused on producing results	Focused on mentee's experience
Research project is mentee's own	Research project is a team effort
Mentee's ability to work independently and report up to supervisor is highly valued	Mentee's work is supported and guided by the coaching mentor
Characterized by hierarchy, boss/subordinate	Characterized by mutual trust, team collaboration

Methods

An explanatory mixed-methods approach is utilized for the larger comprehensive study of the *YOU'RE@CU* Mentoring Program. Initial quantitative data consisting of survey items on the program application and pre-survey are collected, analyzed, and findings used to inform the

subsequent qualitative stage of data collection and analysis. Qualitative data in the form of participant responses to online *reflective questions* are collected periodically during the program's semester-long duration from both graduate mentors and undergraduate mentees. At the conclusion of the program, mentors and mentees complete post-surveys that include both quantitative rating scales and open-ended qualitative responses. Survey items for undergraduate mentees are derived partially from the Academic Pathways of People Learning Engineering Survey (APPLES), and partially from the Assessing Women and Men in Engineering (AWE) Pre- and Post- Engineering Mentee Surveys.^{10,11} The AWE Pre- and Post- Engineering Mentor Surveys are used for pre-and post-assessment of the graduate mentors.¹¹ The online *reflective questions* are written by the program directors and research team and are intended to capture the honest opinions and genuine experiences of program participants as they undergo the research and mentoring process. The full set of *reflective questions* posed to graduate mentors in years 1 and 2 of program implementation are appended in Table 3 for reference.

The initial emergence of the supervisory and coaching mentoring models occurred inductively through careful analysis of two exemplary cases.⁷ Once the salient features of both models were well understood for those two cases, the remainder of the qualitative data collected in 2012 was analyzed per each mentoring partnership to understand if and how the coaching and supervisory models of mentoring were enacted in each pairing. The subsequent examination of data enabled classification of each mentoring pair into the two emergent research mentoring models, with several unclassifiable partnerships that did not neatly align with either the supervisory or coaching models; these cases were saved for future discussion and are not presented here. Overall, the unit of analysis consisted of a single mentoring pair, with qualitative data laid out temporally as collected during the semester as narrative text displaying the mentoring relationship's trajectory from the viewpoint of mentor and mentee. No explicit coding process was employed, but an implicit analysis structure imposed by the characteristics of supervisory and coaching models was used to categorize each mentoring pair.

This paper focuses on solely qualitative data to tell the how and why of the coaching and supervisory models of mentoring as seen through six overall mentor/mentee pairs. Quantitative data collected via Pre and Post Mentee and Mentor Surveys are not analyzed here—the qualitative development of mentoring relationships as told through mentor and mentee words are presented.

Results

The following section includes three examples of mentoring pairings for both Coaching and Supervisory models, illustrated via qualitative data collected from both mentors and mentees within the partnership. The intent is to show through selected quotations how the proposed research mentoring models exist and apply to each of the mentoring relationships, regardless of gender composition, research area, type of laboratory or experimental work, etc. The coaching model is explained first from the perspective of 3 mentoring pairs: Mia and Annie (both female), Nate and Scott (both male), and Russell and Rachel (male mentor and female mentee). The supervisory model follows, as demonstrated by Dwayne and Amelia (male mentor and female mentee), Keeley and Veronica (both female), and Drake and Shannon (male mentor and female mentee). These gender pairings are summarized in Table 2. **Error! Reference source not found.**

Table 2: Summary of Mentor/Mentee Name and Gender, Type of Mentoring Model Enacted, and Presence/Absence at Mentor Training

	Mentor name	Attended Training?	Mentee name	Mentor gender/Mentee gender
Coaching	Mia	Yes	Annie	Female/Female
	Nate	Yes	Scott	Male/Male
	Russell	Yes	Rachel	Male/Female
Supervisory	Dwayne	No	Amelia	Male/Female
	Keeley	Yes	Veronica	Female/Female
	Drake	Yes	Shannon	Male/Female

Coaching Model – Mia and Annie

The coaching model of mentoring is exemplified by the relationship between graduate mentor Mia and undergraduate student Annie established in 2012, during the second year of the YOU'RE@CU program implementation. At the outset of their partnership, Mia, a 4th year PhD candidate in Mechanical Engineering explains her hopes for her participation in the mentoring program:

I hope to create a positive research experience for the undergraduate student I work with....I generally have concerns that the research will either be too boring or too complicated for the student. I'd like to ...help build her interest in the research.

Mia's overriding concern is that her mentee, Annie, has a positive overall experience and is genuinely interested in the research. In a subsequent reflective question response, she describes the working environment she creates with Annie:

I'd like to keep the experience positive and manageable but sometimes I feel like I have trouble determining the right balance...when we have a short meeting things don't go quite as planned I get concerned that the student is having a discouraging research experience...I try to welcome and explain all my student's questions.

Mia's consideration for Annie is clear in the importance she places on keeping her experience balanced and not too boring or too complex. The focus is on Annie's interest in the research, not on the research itself. Mia continues:

She [Annie] has been doing good work and I feel like she is almost ready to work independently, which also makes her a valuable lab asset...I feel that my mentee has done a good job working with me and completing the tasks that we determined at the beginning of the semester.

By being welcoming of her mentee's questions and in working together, Mia reflects by the end of the semester that she feels her mentee has done a good job collaborating with her and is almost ready to work independently as an asset for the lab.

A brief check-in with Annie, Mia's undergraduate mentee, illustrates her perspective on being mentored:

She [Mia] is continually asking for my opinion and ideas and letting me shape our project into something we both want it to be....

By referring to it as “our project” instead of “my project” or “the project”, Annie indicates that the work is shared, that her research duties have been part of a team's effort to reach a collaborative goal. This is indicative of the coaching type of research mentoring relationship, as it is based on providing a balanced experience that in Mia's words exposes Annie to research in a “positive and manageable” way, making Annie feel supported with the ability to ask questions and explore aspects of their research independently.

Annie adds:

She [Mia] helped me make the research experience something that I wanted and lets me explore different aspects of the project that are of my own personal interest. My mentor supports my learning...I do feel a sense of loyalty to my mentor... I trust in her...I believe it's a mutual trust too. I want to do well in my work to show her that I am dependable and hard-working since she has shown me these qualities in her work.

In these words, Annie illustrates the importance of mutual trust, another characteristic of the coaching model, to her feelings about Mia in the mentoring relationship. Annie explains how she wishes to reciprocate Mia's dependability and hard work in her own work on their project, another attribute of the coaching model of mentoring.

Coaching Model – Nate and Scott

Looking at the data collected from another graduate student mentor, Nate, another perspective on the coaching model of mentoring is shown:

Although it is my responsibility to provide the necessary instruction, it seems as though sometimes, I am forced to spend more time directly supervising his [my mentee's] work than I'd like to...As I try to implement a more Socratic approach that attempts to allow him to answer his own questions, I am caught between the need to leave him alone so that he can reflect on my initial guidance and his need to be guided more intricately. These students are just so low level that, not only are they lacking knowledge, but are also not able to think on their own....Students that are this young are really just too inexperienced to do research without a great deal of help. Nevertheless, this was expected, and I have always assumed that the goal of this program was to provide students with a valuable experience, not for them to provide me one.

Though Nate is spending more time than he'd like with his mentee and refers to his mentee's skills as low-level, he echoes Mia in the thinking that the goal of the program is to provide the mentees with a valuable experience, not for the mentees to provide research help for the graduate

mentors. Nate's phrasing is somewhat misleading, however, as it positions the mentoring experience that he is experiencing as a graduate mentor as less valuable than the experience of being mentored that his mentee is experiencing, though they are two sides of the same coin. He continues:

With one student, it is assumed that the advising is continuous and direct observation of the student's work.... thus fostering a closer relationship with the student where an interest [is] the outcome of your combined efforts...My interests were really that he learn as much as possible and that he gain a liking of graduate research and academics in general. So it was really that I had his best interests in mind.

Here Nate emphasizes once more his focus on providing a positive experience for his mentee with graduate research and academics in general as part of the mentoring program. He explains how he initially assumed that his mentoring responsibilities included fostering a close relationship with his mentee through collaborative work – he remarks on maintaining interest in their combined efforts, not their individual tasks. Nate explains his altruistic focus on his mentee's best interests in participating in the program, not his own.

Nate's mentee, Scott, provides the following perspective on working with Nate:

His [my mentor's] guidance allows me to thoroughly understand necessary concepts while still experiencing self-reliance. We spend time working and solving problems together rather than separately.

This view helps complete the picture of Nate and Scott's mentoring relationship as one built from collaborative teamwork that still allows Scott to experience self-reliance. These are indicative of coaching model of mentoring, as mentor and mentee work together on a shared project to reach a cooperative outcome while still allowing space for the mentee to be independent and demonstrate competence on their own.

Scott adds:

I am confident that my mentor, Nate, has had my best interests at heart throughout the semester. He spent as much time as necessary ensuring that I understood the concepts necessary to do any work, and gave me tasks that were meaningful learning experiences... much of the research we were doing had been done by no one else, making it very special to me. The specialized nature of my training made me feel as though I was doing an important job.

By explaining how Nate made him feel supported and the shared work special during the semester, Scott demonstrates several characteristics common to the coaching model of mentoring. In referring to the "research we were doing," Scott emphasizes the collaborative nature of their work, at the same time he expresses his enthusiasm in how they were the only ones doing this work, together.

Coaching Model – Russell and Rachel

We turn to one more mentoring relationship between graduate mentor Russell and his mentee Rachel to illustrate further aspects of the coaching model of mentoring. Russell explains:

I am in a unique situation...I am the only graduate student working in her [the PI's] lab.... I am worried that the lack of research camaraderie is a detriment to both my student and me in the research/mentoring experience...that said I believe this is becoming a rewarding experience for both of us. The work is completely our own...Next week will be the first week my student will be able to work independently and contribute work on her own. That said I am enjoying the mentoring experience. It is nice to have an extra set of hands. I have been able to teach. Exposing my student to our project has allowed me to relay concepts she has not been exposed to in the past. I believe I have been fairly effective in my teaching methods.

Despite the fact that Russell does not have other graduate students in his research lab and is concerned about the “lack of research camaraderie” or lack of research community readily available for his mentee, he is still able to make the research mentoring relationship rewarding through his efforts in teaching Rachel about the research and in explaining concepts that she has not been exposed to previously. In calling the work “completely our own,” Russell is marking the project as completely shared, though he also sounds excited for the next week, when Rachel will be working independently and contributing work independently. This is similar to the coaching mentoring relationship between Mia and Annie in that the mentor is supporting the mentee through paired work, then carefully supervises and celebrates when the mentee can work independently. The coaching model of mentoring also encourages the reciprocal nature of effort between paired mentor and mentee within a relationship. Russell describes:

Her [my mentee's] effort has been apparent and I like to work with those individuals who put forth effort. I like to reciprocate the effort shown by putting in more effort so she has an experience worth her effort. It has been a give and take relationship from both sides from the start...She [my mentee] is very comfortable running experiments solo and with ease. However, I think she is lacking in data analysis and presentation. This is only because the project has not gotten there yet.

In this passage, Russell’s meaning is unmistakable as he values effort from his mentee and wishes to reciprocate her efforts to create a worthwhile mentoring relationship. By calling the relationship ‘give and take’, Russell illustrates how their relationship requires equal buy-in from both parties to be successful, and how both mentor and mentee are capable of giving and taking as they share together in participating within the relationship. Russell alludes to further teaching and learning he will guide his mentee Rachel through, as the project will get to the data analysis and presentation stage shortly.

Finally, Rachel comments on her mentor Russell’s efforts as follows:

I feel like he [my mentor] has given me a lot of really valuable experiences that will continue to give me good opportunities in the future.

Here Rachel is expressing gratitude for the experiences that Russell “gave” her that she believes will lead to additional opportunities, as she feels that Russell’s mentorship will lead her to future good. The presence of trust in the mentoring relationship is also indicative of the coaching model of mentoring, as both mentor and mentee trust one another to reciprocate effort and lead to mutual benefit.

Later in the semester Rachel states:

He gives me the help I need while not over-explaining so that I can figure things out on my own. He lets me have freedom, which is nice and asks for my input, but I would say that my tasks are very directed by him...Overall, I feel like compared to my classmates mentors, he seems to be one of the best.

Rachel’s statement is indicative of a balanced mentoring relationship that encourages independence and exploration while simultaneously providing support and guidance to an ideal degree, as exists in the optimum coaching model of mentoring. Her high rating of Russell’s mentoring style and him personally as a mentor is a striking review of her experience with the coaching model of research mentoring.

As shown by the mentoring relationships between Mia and Annie, Nate and Scott, and Russell and Rachel, the coaching model of mentoring has the following characteristics: providing a balanced experience that exposes the mentee to research in a “positive” way, mentees and mentors care for one another and attempt to reciprocate efforts, mutual trust exists between mentors and mentees, and mentees feel supported with the ability to ask questions and explore aspects of their research independently though the overall project is shared.

Supervisory Model – Dwayne and Amelia

The supervisory model exists in contrast to the coaching model of research mentorship, as demonstrated by the partnership of graduate mentor Dwayne and undergraduate mentee Amelia in 2012. At the initiation of their mentoring relationship, Dwayne explains his motives for applying to the program and how he feels about the relationship at its start:

I hope to gain more mentoring/teaching experience, and a little help with my research...The relationship between my undergraduate mentee and me has been great so far. I don’t have any concerns...my mentee is very motivated and has produced some great results thus far.

From the beginning, Dwayne is interested what he will gain from participation in the mentoring program, not what type of experience his mentee will have. He positions himself as a supervisor in the relationship by discussing the productivity of his mentee. These traits are indicative of the supervisory model of mentoring, as the graduate mentor acts primarily as a boss or superior to the undergraduate mentee. As their relationship continues to develop, Dwayne explains:

I value the relationship I have created with her [Amelia] and would like to maintain this relationship in the future...She has great ideas, has a strong grasp of how to perform research and is self-motivated...I think that she respects me and looks up to me, and I can count on her to contribute ideas and produce results...[she] has impressed me with her abilities, passion, and self-motivation.

Dwayne clearly values and respects Amelia's efforts and work, as she has notably impressed him during the course of their mentoring relationship. Yet this statement also shows how Dwayne considers Amelia at a lower, separate level than he is, as she looks up to him and he correspondingly looks down on her. Instead of collaboration and teamwork with shared tasks and project work, Dwayne remarks on how Amelia can contribute ideas and produce results.

From Amelia's perspective, her work on her project was done largely independent of Dwayne:

I do think he [Dwayne] has my best interests at heart. I think also though that he is a busy grad student and doesn't have a lot of time to be able to have my best interests at heart show...I feel like I just did this whole thing by myself, even though I do think he is a really great guy.

Though Amelia qualifies her statements regarding Dwayne with reassurances that he's "a really great guy," she feels like she did the entire project by herself, without Dwayne. This is indicative of the supervisory model of mentoring, as the mentee worked independently to complete tasks and then report progress up to the supervisor. To Amelia, Dwayne is a "busy grad student" and may not have a lot of time to show that he cares about her best interests, displaying that a caring relationship between mentor and mentee is not critical under the supervisory model of mentoring.

Supervisory Model – Keeley and Veronica

The supervisory model of mentor is similarly illustrated by the relationship between graduate mentor Keeley and undergraduate mentee Veronica during the same year of program administration. Keeley starts:

I am concerned that I will be a bad mentor...My mentee is very motivated, and has done a fantastic job letting me know when I am doing a bad job – which has made the relationship both productive and hopefully inspiring (at least it has been for me).

Honest about her concerns at the initiation of their mentoring relationship, Keeley explains how she is already benefiting from being a mentor and how mentoring is a productive activity so far. The focus on productivity is one attribute of the supervisory model of mentoring. This develops further along with the mentoring relationship, as Keeley tells:

My mentee [Veronica] generally did a great job and was helpful not only with her project but on several occasions with general lab and/or project asks as well...Although my mentee was aware that the project she was working on was her own, she understood that it's effectiveness and usefulness depended on how

well it integrated with the larger project. I did feel sometimes though that she was sometimes overly concerned with my interests to the point that it detracted from her research experience – as she was less willing to make final decisions about her project without my approval.

Keeley's explanations here are aligned with the supervisory model of research mentoring in that Veronica's project is "her own" – despite the fact that it fits with Keeley's larger project it is still viewed as uniquely Veronica's and separate from the rest of the work. Keeley refers to "her project" and "her research experience", further illustrating how Keeley views Veronica's work as separate from her own, similar to Dwayne and other supervisors under this model of mentoring. Interestingly enough, Keeley sees this as a limitation that may have "detracted" from Veronica's research experience, as Veronica was hesitant in making final decisions about "her project" and wished to check with Keeley's interests before making her own progress.

Meanwhile, Veronica perspective also demonstrates the supervisory model of mentoring. She says:

In spite of her [Keeley's] serious outlook towards her work, she was still willing to bring me into her lab, and share her work with me.

This simple sentence clearly shows how Keeley's work exists separate from Veronica, as Veronica calls it "her work" (Keeley's work) multiple times. It is also noteworthy that Veronica is positioning herself subordinate to Keeley in that Keeley, the superior with a serious outlook towards work, was willing to bring Veronica in and introduce her to "her lab" and share "her work" with Veronica. This further indicates that Keeley has some degree of ownership of the lab, in Veronica's eyes at least. The way Veronica uses the word "share" here is not in a collaborative sense, instead it reinforces Keeley's power to choose what aspects of her work she wishes to include Veronica in. As the mentee in the supervisory model of mentoring, Veronica sees her work as separate from Keeley's and looks up to Keeley.

Veronica adds:

I think at first she [Keeley] was not sure how to be a mentor, having never done it before, but over time she has come to be really helpful. She was truly willing to share her research with me; it just took her a bit of time before she could trust me, and that is completely understandable. Though I am helping her with my research...I am going to continue helping her in the future until we are both satisfied with the outcome of my project.

This fascinating excerpt from Veronica shows aspects of the supervisory model of research mentoring. She refers to "my project" and "my research", reinforcing the separation between Keeley's work and her own. Veronica explicitly discusses trust, and attributes a slow project start to the need to establish a trusting relationship before Keeley would share the research with her (again illustrating the separation and ownership of Keeley's work vs. Veronica's). In discussing trust and reciprocity in helping one another during the mentoring relationship, Veronica's statement sounds partially aligned with the coaching model of mentoring. Yet the overriding

sentiment appears to be the separation between “her work” (Keeley’s) and Veronica’s own project, and is still strongly reminiscent of the supervisory model of research mentoring.

Supervisory Model – Drake and Shannon

The mentoring relationship between Drake and Shannon is another example of the supervisory model of research mentoring, noteworthy in that Drake is a foreign national and a non-native English speaker paired while Shannon is a domestic undergraduate student with English as a first language. At the outset, Drake has a slightly different perspective on his expectations on participating as a graduate mentor:

I clearly want to emphasize the importance of responsibilities and professionalism. Other concerns are keeping track of their progress and encouraging them in their thought process and approach. I think having an idea about your weakness actually can help you better in the mentoring process... As a mentor I want to keep the relationship as professional as we could. I only value the academic relationship with them.

Clearly, Drake views mentoring as a process that exists only in the professional domain, with no social component required or appropriate. The mentoring job description that Drake signed up for does not explicitly include trust or social nurturing. By discussing how he wants to keep track of his mentee’s progress, he is illustrating the results-focused outlook typical of the supervisory model of mentoring. As the relationship develops and progresses, Drake explains how he perceives his mentee Shannon:

My mentee [Shannon] was very cooperative throughout the semester and rightly understood the importance of the effort I am putting from busy graduate schedule...She tried hard to make up the education she was lacking for the research. Based on this I felt she was very helpful for the research and also showed the correct attitude.

Generally Drake takes an evaluative tone of his mentee Shannon, as he calls her attitude “correct” and her understanding “rightly” to indicate alignment with his expectations as a supervisor. By describing her education as “lacking” and explaining the importance of his efforts in the research mentoring relationship in the context of his busy graduate student schedule, he is positioning himself as superior to Shannon in that his efforts and his time are valuable and his education complete.

On the other hand, Shannon, Drake’s mentee, states:

I think the main reason that he [Drake] is good at research is because he approaches problems with an open mind. Therefore I think that my mentor is very helpful and very good at research.

Here, Shannon takes an evaluative approach to assess Drake as a mentor, similar to how Drake assessed Shannon as a mentee. She cites his open-minded approach to problems as the main reason he is good at research, though she neglects to explain if that also makes him good at

mentoring. There is no mention of any social aspects of Drake as a mentor, in line with his desire to keep the relationship purely academic.

Shannon says:

My mentor was also very available if I had questions or needed help on an assignment. I feel that I have learned a lot from my mentor and had a good experience.

This passage illustrates again that Drake was a very professional and academically oriented mentor; Shannon had no difficulty approaching him regarding help on assignments, for instance. She emphasizes that she has learned from her mentor and had a good experience, but does not provide any non-academic details on how or why the experience was good.

Overall the supervisory model of mentoring is illustrated by the partnerships of Dwayne and Amelia, Keeley and Veronica, and Drake and Shannon, and has the following attributes: a focus on the mentee's production of results as a barometer of success, the mentee in a subordinate position to the mentor, the mentor seeing themselves as busy and superior to the mentee, and the mentee perceiving the research project as their own work, not shared with their mentor.

Discussion and Conclusions

Looking at qualitative data across six different mentoring partnerships in 2012 illustrates several aspects of the two proposed models of research-based mentoring relationships. The coaching model of mentoring, as demonstrated by Mia and Annie, Nate and Scott, and Russell and Rachel, focuses on the mentee's experience as the undergraduates are exposed to engineering research for the first time. It is noteworthy that Mia, Nate, and Russell were among the 8 mentors in 2012 that attended the initial mentor training session, received formal mentoring guidelines and a checklist of mentoring tasks for program participation, and got feedback on their proposed research projects for their mentee before the actual start of their mentoring relationships. The supervisory model of mentoring, on the other hand, as shown by Dwayne and Amelia, Keeley and Veronica, and Drake and Shannon, prioritizes the production of results from the mentee. Interestingly enough, Keeley and Drake did attend the mentor training session, but Dwayne was in the cohort that missed the training due to a weather-related campus closure and inability to reschedule a make-up session. Though Keeley and Drake were given the same formal mentoring guidelines and checklist of mentoring tasks as the mentors that exhibited the coaching model, they adopted a supervisory model of mentoring in their interactions with their mentees. In this way the mentoring training session held in 2012 was apparently inadequate in setting up all mentors with the same expectations and criteria for mentoring relationship success. Given the same training materials, the graduate mentors independently diverged into the two proposed models of research mentoring: coaching and supervisory.

It is also noteworthy that the both coaching and supervisory models of research mentoring relationships were exhibited by both same-sex and mixed-sex mentoring pairs of all gender combinations available: both female, both male, male mentor and female mentee. Practical considerations limited the availability of female mentors as there were far more undergraduate female applicants for mentee positions than available graduate female mentors, as typical of engineering population demographics. While some mentoring literature encourages same-sex mentoring pairings for optimum success in the social domain of mentoring relationships, this

may be less pertinent for research-based mentoring relationships like those under study in the YOU'RE@CU mentoring program.¹² Recent studies also indicate that increasing the number of women in a technical environment does not necessarily result in increased recruitment of women into that environment, indicating that some women do not feel the need to gravitate towards exclusively female advisors or mentors.¹³ Besides, given the roughly 80% male to 20% female gender imbalance in engineering, it is not realistic to assume that same-sex mentoring pairs for young engineers will be possible when the undergraduate population significantly outnumbers the graduate student population.¹⁴ In 2012 at least, the genders of the mentor and mentee did not affect the likelihood of adopting a supervisory or coaching model of mentoring; the presence or absence of gender effects will continue to be studied in future years of program implementation. Gender differences in management and leadership styles have been documented in a variety of studies, but findings generally suggest that the context in which managers act must be well understood to gain a holistic view of what makes some managers and leaders more effective than others in different situations.¹⁵⁻¹⁷

One of the continuing difficulties in administering the YOU'RE@CU mentoring program is the ongoing recruitment of graduate mentors wishing to participate in the semester-long experience. As the program now in its third year continues to establish a foothold within the landscape of outreach and service opportunities within the College of Engineering and Applied Science, what is to differentiate this research mentoring experience from serving as an informal mentor to young undergraduates doing an independent study or other types of informal mentoring opportunities? Participation in a formal mentoring program requires additional effort from the graduate students as they must apply to the mentoring program, attend mentor training, and commit to supervising their undergraduate mentee within the program guidelines of 3-5 hours per week. As many of the graduate mentors and their undergraduate mentees state, it can be hard to make time in the busy graduate student schedule to allow for this type of program participation. Consequently, identifying and communicating how the program benefits graduate students during and after their graduate education is critical to recruiting and attracting graduate students.

The development and continued study of the two emerging models of research mentoring, coaching and supervisory, help frame the discussion of what graduate students can tangibly get out of participation in the mentoring program aside from a mention on a curriculum vitae or resume. One of the program's stated goals is to provide graduate students with hands-on mentoring experience; in fact that is arguably the most important part of the program. Yet, just providing the experience may not be sufficiently compelling to motivate busy graduate students to apply and participate in the mentoring program—adding relevant and specific details of lessons learned based on the supervisory and coaching models of mentoring may help convince the graduate students that this mentoring program is indeed worth their time. Experiences from both supervisory and coaching-style mentors can help future mentors set expectations and create accepted best practices for mentoring in this type of semester-long research-based relationship. This experience also allows the mentors to start to establish their teaching philosophy, which is a critical piece of their application package as they apply for academic positions. Few graduate students have teaching experience outside of a TA position—which makes it difficult to formulate a teaching philosophy at this point in their career.^{18, 19} For graduate students who are interested in remaining in academia and eventually running their own research group, the process

of mentoring and managing more novice researchers can be informed by the experience of serving as a YOU'RE@CU mentor. These benefits in turn add to what program administrators can advertise to the graduate students as benefits of participation in the program, and may help subsequently to attract and recruit graduate mentors to apply.

Future Work

As the YOU'RE@CU program enters its third year of implementation, mentor training will continue to be improved and targeted based on findings from the supervisory and coaching models of research mentoring observed in 2012.

In addition to improving and streamlining the mentor training sessions based on the findings of the two proposed models of mentoring, the data collected from the third year of program implementation will also serve to further refine and define what constitutes the coaching vs. supervisory models of research mentoring. The continued development of these models of mentoring will also be informed by additional longitudinal data collection as the research team looks to follow-up on the experiences of past mentor and mentee participants, to see how the graduates and undergraduates remember their experiences in the YOU'RE@CU program and if they perceive their program participation as affecting their trajectory through their degree program in any way.

While this paper focused predominately on the perspective of the graduate mentor and outcomes of program participation for graduate mentors, future work will include tying together mentor and mentee perspectives to gain a more holistic picture of the supervisory and coaching models of mentoring. Looking at the pre-/post- comparisons of quantitative survey scales for both mentors and mentees may also shed light on other measurable aspects of coaching vs. supervisory mentoring relationships, to further supplement the findings from the qualitative data presented here. Finally, data collection instruments including pre- and post-surveys and ongoing reflective questions will be adjusted with these two salient models of mentoring in mind, to further probe and tease out characteristics or attributes of each type of mentoring model.

The implications of the two mentoring models will also be studied further as work on this project continues. As graduate mentors who were trained similarly in 2012 still independently diverged into the supervisory vs. coaching models of mentoring, it is worth studying what types of assumed expectations or previous experiences lead a graduate mentor towards the supervisory vs. coaching path. One hypothesis by the authors is that mentors tend to mentor the way they have been previously mentored themselves, in the case of a graduate student it is entirely possible that the way their thesis advisor has mentored them affects the way in turn they will mentor an undergraduate student. If indeed mentoring style is a self-perpetuating cycle originating from the mentoring style of the thesis advisor, one wonders how it is possible to break or change the cycle from one model to the other. Future surveys of thesis advisor mentoring style may add to the understanding of how these proposed models of mentoring emerge and how they can potentially be changed to improve the overall experiences of mentors and mentees alike.

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Appendix

Table 3: Graduate Reflective Questions, Year 1 and 2

2011 (Year 1) Graduate Reflective Questions	
1	Do you feel like an effective mentor to your student? Why or Why not?
2	Do you feel you have helped your student to greater understanding in the lab and research community? How do you think mentoring fits in the academic environment? Ideally, how would mentoring fit in an academic career?
3	Have you enjoyed working with your student in the research environment? What would make the mentoring experience better for you overall? How could the mentoring experience be improved?
2012 (Year 2) Graduate Reflective Questions	
1	What concerns do you have as a graduate mentor in initiating the research relationship with your undergraduate mentee? Do you think you have areas of weakness, vulnerabilities, or strengths that factor into the mentoring process?
2	Do you as a graduate student feel a sense of loyalty to your undergraduate mentee? Do you value the relationship you have created with them? Would you want to maintain this relationship in the future? Please explain. Do you think your mentee has the ability to be a good mentee? Do they have the ability to do the required research? Please explain.
3	During the course of this semester, have you felt that your mentee has had your best interests at heart?