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Guiding Undergraduate Researchers in the Virtual World: Mentoring Experiences of Globally Distributed Students

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Abstract

The advancement of technology has led to an increase in undergraduate students pursuing degrees online. The translation of undergraduate research to the online environment is relatively new,

though gaining momentum, partly due to the COVID-19 pandemic. Mentoring is a key undergraduate research support, particularly for those engaged online, as it fosters a supportive environment for online students to develop their skills and knowledge in their field of study. This study aims to explore the positive impacts of mentoring undergraduate research for fully online students. A single case study methodology was used, with interview data collected from four research mentees completing their degrees fully online. While this study is exploratory and further research with a larger sample size is necessary, the preliminary findings suggest that virtual mentoring can lead to a stronger sense of belonging, enhanced understanding of research processes, professional development (including career path and transferable skills), and continuous personal growth. These results highlight the importance of providing research mentoring opportunities to online students.

Keywords: Undergraduate research, virtual mentoring, STEM, online learning

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Undergraduate research is a high-impact practice, with well-documented student benefits, including gains in research-specific and transferable skills (Brewer et al., 2012). Particularly for underrepresented groups, participation in undergraduate research can bolster STEM degree persistence (Chang et al., 2014). Mentoring is a widely embraced best practice to support undergraduate research (N. Hensel, 2012; Vandermaas-Peeler et al., 2018) and offers numerous potential benefits, including improved perseverance in research experiences (Cooper et al., 2019), gains in self-efficacy (Sams et al., 2015), enhanced scientific literacy skills (Sams et al., 2015), positive impacts to attitudes towards their major

(Rodríguez Amaya et al., 2018), and bolstered personal identity (Palmer et al., 2015).

Defining Mentoring

Mentoring, a well-studied concept, has various definitions in the literature including conflation and confusion with terms like role modeling and advising (Palmer et al., 2015). A functional definition of mentoring is “a mutually beneficial collaborative learning relationship that proceeds through purposeful stages over time and has the primary goal of helping mentees acquire the essential competencies needed for success in their chosen career” (National Academies of Sciences, Engineering, and Medicine, 2017; Pfund, 2016; Short, n.d.). Research mentorship definitions often incorporate terms like advisors, supporters, tutors, masters, sponsors, and identity models (Thiry & Laursen, 2011). The Council on Undergraduate Research defines undergraduate research as “a mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge.” (Undergraduate Research Definition Task Force, n.d.). This definition clearly defines a mentoring role. However, not all undergraduate research supervisors view mentorship as their responsibility (Brewer et al., 2012).

Undergraduate research mentors have three primary roles, comprising of career functions, psychosocial, and role-modeling (Pfund, 2016). Career functions encompass professional socialization (Thiry & Laursen, 2011), career and professional development (Abedin et al., 2012), sponsorship (National Academies of Sciences, Engineering, and Medicine, 2017), and coaching. Psychosocial support involves personal and emotional support while role-modeling includes providing intellectual support (Thiry & Laursen, 2011). Faculty roles may vary with their mentoring style and mentee goals.

Mentoring Skills

Effective undergraduate research mentors possess specific knowledge, skills, and attributes, grouped into four categories: 1) building positive relationships, 2) tailoring mentorship to individual student needs, 3) monitoring students' daily tasks, and 4) building a personal relationship with students (Ahn & Cox, 2016). Mentors possess critical knowledge about students' knowledge gaps, goals, projects, and research skills (Ahn & Cox, 2016). Mentors exhibit key skills including availability and approachability, communication, project management, independence, and teamwork (Ahn & Cox, 2016). Mentors embody key attributes including care, facilitation of learning, patience, respect, enthusiasm, and humility (Ahn & Cox, 2016).

Evidence-based best practices enhance undergraduate research mentorship. Strategic pre-planning addresses diverse student needs and abilities and allows for the scaffolding of opportunities (Shanahan et al., 2015). Building a community involving multiple stakeholders requires strategic pre-planning where setting clear, scaffolded expectations is essential. Mentors can apply a sociocultural perspective of understanding STEM identity to support mentee identity development, meaning the mentor recognizes and leverages the impact of social and cultural factors on how individuals perceive themselves, actively engaging with mentees to create a supportive and inclusive environment where identity development can occur (Davis & Jones, 2017). Many of these best practices line up with specific role domains. For example, best practices in the career functions domain involve teaching technical skills (Shanahan et al., 2015), developing mentee identity and independence as a researcher to promote self-efficacy, agency, and project ownership (National Academies of Sciences, Engineering, and Medicine, 2017; Shanahan et al., 2015), and facilitating networking by explaining disciplinary norms, and

providing guidance on research dissemination (Shanahan et al., 2015). This career function domain is important as students may struggle to translate what they have learned through their undergraduate research to an employability or non-research-work context (Carpenter et al., 2022). In the psychosocial domain, mentors balance rigorous expectations with appropriate support (Johnson et al., 2015; Shanahan et al., 2015) and dedicate time to one-on-one mentoring (Shanahan et al., 2015). Role modeling entails modeling how to do research, critiquing decisions, and demonstrating ethical research practices (Davis & Jones, 2017). These practices correlate with "active mentoring" behaviors that promote strong identity development as a researcher (Davis & Jones, 2017; Palmer et al., 2015)

Barriers to Research Mentorship

Obstacles to undergraduate research mentorship include institutional, departmental, and individual challenges. At the institution level, promotion, tenure, and evaluation systems may not adequately recognize faculty commitment to mentorship (Morales et al., 2017). This issue is exacerbated by the predominance of contingent (adjunct and non-tenure track) faculty, as mentorship is less likely to be valued in such positions. Faculty who are teaching online are even more likely to be employed on a contingent line (Hurlburt, 2016). Departmental leadership may inaccurately estimate the extent of mentorship taking place (Johnson, 2015).

At the individual faculty level, obstacles to mentorship include the downstream impacts of reward systems, faculty support structures, and the characteristics established through hiring practices, as well as individual faculty attributes and attitudes (Lunsford et al., 2013). At the individual student level, obstacles to mentorship include time and motivation (Bangera & Brownell, 2014), which may be compounded in an online environment. While some research has explored undergraduate research for online students, the recent

COVID-19 pandemic has necessitated closer attention to overcoming undergraduate research barriers in the online environment (N. H. Hensel et al., 2022; Pfund, 2016; Qiang et al., 2020).

Evaluating Mentoring

Successful mentor-mentee relationships produce mentees with personal and professional skills, knowledge, and confidence necessary to meet career and professional goals (Pfund, 2016). Various instruments have been developed to assess the impacts of research mentoring relationships using measures like graduate school advancement, STEM degree persistence, self-efficacy, and disciplinary identity. The Undergraduate Research Student Self-Assessment (URSSA; (Weston & Laursen, 2015) measures disciplinary thinking and skills as well as personal gains and attitudes. The Survey of Undergraduate Research Experiences (SURE) measures perspectives regarding learning gains and aspects of a research program (Lopatto, 2004) The Office of Student Scholarship, Creative Activities, and Research (OSCAR) survey was designed for program-level assessment (Foster & Usher, 2018). The National Survey of Student Engagement (NSSE) also contributes to understanding these dynamics (Collins et al., 2017).

However, research is needed to explore the influence of the theoretical core attributes of mentoring relationships on mentee outcomes (National Academies of Sciences, Engineering, and Medicine, 2017; Pfund, 2016), especially in the *online* context. The establishment of a robust theoretical framework for undergraduate research mentoring remains an ongoing need (Pfund, 2016), though recent studies have started to incorporate social cognitive career theory, which connects self-efficacy, career goals, learning experiences, and career planning (Byars-Winston et al., 2015; Carpi et al., 2017; Deemer et al., 2020; Jones et al., 2022). However, the current literature falls short of identifying specific elements in this

theoretical framework. The aim of this paper is to articulate discernable attributes to unravel the influence on mentee outcomes in the landscape of online research mentoring.

Research Questions

This case study was conducted at a medium-sized private institution in the United States offering degree programs that can be completed asynchronously online, supporting a globally distributed faculty and student population. The purpose of this investigation is to explore the presence of the emerging theoretical framework for undergraduate research mentoring, as observed in a virtual mentoring setting. The research questions were:

1. To what extent does mentoring contribute to the development of a stronger sense of belonging within the academic community among fully online undergraduate research mentees?
2. What are the perceived course and career outcomes for fully online undergraduate students engaged in mentoring?

Methods

Study Site Context

The study was conducted at a medium-sized private institution with two residential campuses and one fully online campus. Only undergraduate research mentorship at the fully online campus was evaluated in this study. At the time of the study, approximately 14% of the online undergraduate students were female while 86% were male. The mean age of the undergraduate students was 31. Active military students accounted for 61% of the undergraduate population and 18% were veterans. For ethnicity, 53% were white, 9% black/African American, 5% Asian, and 18% were Hispanic/Latino. The online campus offers 22 undergraduate degree programs, of which 10 are STEM degrees.

The online campus offers key supports for online undergraduate research through a program that provides research-focused workshops, virtual mentoring, and a digital resource center. While the program distinguishes research mentor and supervisor roles, some roles overlap, and the roles are adaptable, allowing for variations in individual mentor-mentee relationships (Table 1). For example, while research supervisors have a clear role in professional socialization (e.g., coordinating research team meetings, facilitating student participation in conferences and workshops, and welcoming students into professional societies), research mentors may also support professional socialization by helping mentees understand field norms and core skills. Research mentors provide ongoing support, guiding students from research curiosity through to research culmination and beyond. Mentors offer emotional and intellectual support, helping students set expectations and goals for the research experience, navigate barriers as they arise, and develop key research and transferable skills. Mentors model STEM identity and attitudes. Mentors tailor their roles to align with their students' objectives. Distinctly, research supervisors typically engage in a shorter-term relationship during the research-active period with the primary aim being to support the completion and dissemination of the research project. While a faculty member may serve as both mentor and supervisor to an undergraduate researcher, the roles are distinct within the program.

Table 1

Research Mentor and Supervisor Roles in the Research Program at Studied Institution

Domain	Role	Mentor	Supervisor
Career Functions	Professional Socialization	X	X
	Career and Professional Development	X	X
	Sponsorship	X	X
	Coaching	X	X
Psychosocial	Personal support	X	
	Emotional support	X	
Role-Modeling	Intellectual support	X	X

Undergraduate research mentors in the program are full-time faculty housed within the College of Arts and Sciences. The research mentoring program was added to an existing mentoring program in the College that originally focused just on career mentoring. At the time of this study, there were four research mentors, with 3 – 6 mentees per mentor. All mentors were research-active tenure-track or tenured faculty. Mentors completed a brief professional development activity designed using best practices from the research literature (Friberg et al., 2021; McKinsey, 2016; Shanahan et al., 2015; Vandermaas-Peeler et al., 2018). The professional development focused on mentoring in (mentee goal and motivation identification), mentoring through (mentee application of skills with growing autonomy), and mentoring onward (mentee self-evaluation of progress). The second professional development lesson addressed the qualities of impactful mentors including active listening, note-taking, self-reflection, proactive communication, and empathy. Finally, the mentors were presented with a description of a mentoring philosophy and example before being tasked with crafting their own.

In this program, research mentoring was fully online, involving globally distributed mentors and mentees. Mentoring frequency was led by the student researcher, as were desired communication methods (e.g., synchronous video, shared documents, emails, etc.). Students had flexibility in joining the program at any stage of their degree and the duration of participation was self-determined.

Mentoring recruitment methods included emails, website announcements, word of mouth, and workshops.

Participants

Interview participants (n=5) were recruited from the existing undergraduate research mentoring program. At the time of this study, the mentoring program was in the pilot phase, with emerging student participation, leading to a small population and thus a small sample size. Only mentees who were active in the mentoring program for at least six months were recruited for this interview to ensure responses to interview questions were well-informed. Meta-themes (first-level codes) can be reliably identified with very few interviews, with saturation (where no new information is observed) occurring for second-level codes at twelve interviews (Guest et al., 2006).

There were three female and two male participants. Three participants were white (non-Latin), one was black, and one was Asian. Two participants were military-affiliated while three were not. Two participants were in the 18 – 25 age range, two were in the 26 – 35 range, and one was in the 36 – 45 range. The research fields of the mentees were social sciences, human factors, STEM education, aerospace engineering, and unmanned aerial vehicles, though all were enrolled in STEM degrees.

Interview Procedure

To address the research questions of this study, one-on-one interviews were performed with active research mentees. As both mentees and researchers are distributed globally, interviews were performed in password-protected Zoom sessions. The sessions were recorded to allow content analysis. Interviews were structured to provide a series of identically presented and sequenced questions to participants. While the overall interview consisted of 11 questions, a subset of the interview was used in this study to

address the research questions (Appendix 1). Most interview questions were researcher-generated based on a thorough review of the research literature, but the self-efficacy questions (questions 7 – 9 of the interview) were adapted from a previously published instrument (Concannon & Barrow, 2009). The interviews were estimated to take 45 minutes. This study was reviewed and deemed exempt by the institutional review board (Approval #22-135).

Data Analysis

Interviews were transcribed using Microsoft Word and pseudonyms were assigned to ensure confidentiality. Data analysis used both deductive coding, aligning with existing models on STEM identity, self-efficacy, and skills assessment, and inductive coding to enable the emergence of new themes directly from the data. Constant comparison refined deductively generated codes to align with emerging themes and to adjust inductively generated codes to incorporate relevant aspects of existing theories (Fram, 2013). All codes were agreed upon through discussion among three coders, maintaining a balance between existing theoretical frameworks and new data-driven insights.

Results and Discussion

In the following section, we present the outcomes of our thematic analysis that used the hybrid deductive and inductive coding approach to elucidate key themes and patterns derived from the interviews. The results of the thematic analysis are presented in Table 2. Four major themes emerged, with the Learning Community code aligning with the first research question and the codes of Understanding the Research Process, Professional Development, and Continuous Growth aligning with the second research question.

Table 2

Emergent Themes Resulting from Blended Inductive and Deductive Coding of Interview Responses

Code	Sub-code	Frequency
Learning Community	Mentor support	9
	Connection	5
	Peer Support	3
	Recognition	1
Understanding research process	Initializing Research	3
	Nature of Research	3
	Disciplinary Focus	2
	Research Management Skills	2
Professional Development	Transferable Skills	10
	Career Path	4
	Resume Building	2
Continuous Growth	Self-Efficacy	5
	Lifelong Learning	3

RQ 1: Development of Sense of Belonging through Virtual Research Mentoring

Mentor Support

The most common theme to emerge within the responses coded as learning community was mentor support. Mentee responses included “I don’t think I’d be able to do it without the mentors, honestly, as an undergrad student there’s still so much to learn.”, “[My mentor] reignites my passion for the research that I’m doing.”, and “If I have questions about anything I can go turn to them. Or if I need any kind of advice or guidance about higher level topics, I have a resource to answer those questions.”. One mentee’s comment on mentor support pointed to a true collaboration, stating “I feel more like I’ve got a partner in my research, rather than it’s just a professor-student relationship…”. The capacity of the mentor to inspire mentees was clear with one mentee’s thoughts, sharing “She inspires me a lot on, like, just how much she does.”

Connection

Research mentees also expressed that mentoring engendered a sense of connection. One student noted their connection to their mentor in comparison to other interactions with faculty through their degree progress, stating “I'm surprised about the connection I've developed to a faculty member. As an online student, it's kind of hard to develop real relationships with professors in classes.” Mentees also opined on their connections to the broader community, as seen in the following responses:

- “I can see myself as, like, one element of a larger system. My role is small but it’s still important.”
- “Us as researchers…”

Peer Support

Research mentees also pointed to how the mentoring program promoted peer support, which was an interesting finding considering the one-on-one nature of the virtual mentoring program. The responses point to how students are envisioning themselves in the larger research community. Mentees shared the following:

- “I’m in a field where there’s not a lot of people like myself.” And “I can inspire others through the work that I’m doing.”
- “Some of the stuff that I had learned, I might be able to help other students, things that I wish other students could have told me when I first went through it.”
- I would want to, you know, pay it forward, if that makes sense. To Try and help other individuals if they ever need it.”

Community and Identity

Peer and mentor support, along with the concept of connection, are integral elements of a community. A person’s sense of belonging, identification, and self-concept within the fields of science, technology, engineering, and mathematics is known as STEM

identity, which is developed through 1) evaluating one's competence in STEM knowledge skills and abilities, 2) demonstrating these competencies through performance opportunities, and 3) receiving acknowledgment and recognition from experts in STEM disciplines (Carlone & Johnson, 2007). Research suggests that engaging in undergraduate research enhances STEM identity (Betz et al., 2021), but students engaging in research online may feel isolated from the STEM community (Roehrig et al., 2022). Research mentorship has been shown to nurture a strong STEM identity (Ero-Tolliver et al., 2021). In our interviews, the theme of recognition emerged only once, with a mentee stating, "It was very shocking to have won that award …".

The subthemes that surfaced from the interviews related to a learning community were consistent with advantages observed in traditional research mentoring settings, such as enhanced research perseverance (Cooper et al., 2019) and personal identity development (Palmer et al., 2015). These emergent themes align with specific mentor roles within the psychosocial domain, particularly in providing personal and emotional support. The interviews revealed instances of how the mentors are applying best practices in this psychosocial domain, combining high expectations with personalized support and genuine interest through individualized mentoring.

RQ 2: Course and Career Outcomes from Virtual Research Mentoring

Three themes of benefits emerged from the coding of the interview responses by mentees engaged in virtual undergraduate research mentoring: understanding the research process, professional development, and continuous growth. While some studies (like (Wolf, 2018)) evaluating open-ended responses related to research experiences subsume research skills within the broader category of professional development, we posit that research skills and

professional development are distinct constructs. Professional development encompasses a broad array of skills contributing to overall growth, whereas research skills, although integral to the development of the learner, deserve recognition as a standalone entity. Recognizing research skills as a distinct construct is essential because it acknowledges the specialized knowledge and expertise required for successful engagement in scholarly inquiry, highlighting the impact of these skills not only on one's professional development but also on the advancement of knowledge within a discipline.

Research Skills Mastery

Initializing Research. Related to the development of research skills and understanding of the research process, three responses directly addressed how mentoring supported initializing research. One student stated, “I had a research idea that I needed help, like, growing.” Another mentee stated, “I'm looking at situations through a lens of ‘How can I look at this differently to try and find an answer?’, whereas before I may just gloss over it as not an opportunity to research.”

Nature of Research. Three other responses in this theme addressed the nature of research. One mentee shared:

It seems that the research process is done in a way that makes sense. Which, I guess I don't know why that surprises me, but I guess I thought it would be a totally different world and it seems very logical and, you know, real world.

Another commented on hurdles encountered in research, stating “It has surprised me that the actual project itself gets delayed so much, like, because of paperwork. [My mentor]’s really good at explaining them to me and like, why we got stuck and why we have to backtrack…” Students may approach research with a basic understanding of the nature of research, that it is systematic,

objective and unbiased, evidence-based, replicable, and cumulative. However, students may have less exposure to the uncertainty in research, the problem-solving required, the rigor required, the norms related to the communication of results, and how the field may be changing over time (Kershaw et al., 2018).

Disciplinary Focus. In understanding the research process, mentees also reported that mentoring improved their disciplinary focus. One mentee stated, “Now I’m more focused on the topic that I want to go into [with my research].” and continued, saying “I was more naïve … so now I have more knowledge base on how to go about doing certain types of research and just really staying true to the method.” One student commented on their motivation for engaging in research mentoring, stating “I wanted to learn more about professional research as I was doing more of elementary research.”

Research Management Skills. Mentees also identified research management skills in their responses, with both students emphasizing a challenge. One addressed a communication barrier, stating “…trying to coordinate the schedules has been difficult.” The other addressed time management, sharing:

The thing is, [my mentor] doesn't give me hard deadlines. Right? I give myself hard deadlines. But then I find myself having difficulty holding myself accountable to those because there's no real consequence to it. Right? There's no course grade.

Undergraduate researchers at this institution could participate in extra-curricular or curricular research experiences. While there are tradeoffs and benefits for each approach, a course-based undergraduate research experience would address both barriers as communication and a timeline would be built into the structure of the course.

The emergent themes related to research skills development were consistent with the research mentor domain of role-modeling, with a role of providing intellectual support. The emergent themes align with best practices within this role, including explaining disciplinary norms and providing guidance on specific research processes including initializing research, research project management, and more. The interview responses demonstrate how virtual mentorship demonstrates mentoring best practices, with mentors modeling how to do research and critiquing research decisions.

Professional Development

In this interview, several key aspects of research mentorship roles within the career function domain emerged, specifically career development, as evidenced by emergent codes in transferable skills, career paths, and resume-building.

Transferable skills. Throughout the interview responses, mentees repeatedly identified growth in key transferable skills that led to their professional development. Specifically, mentees identified growth in decision-making, critical thinking, communication, project management, and information literacy.

- Decision-making: “Being in the research mentorship program allowed me to see that it’s alright to make mistakes, but don’t get into analysis paralysis where you’re just stuck on decisions and you’re not taking action.”
- Communication: “They teach me how to write or how to ask the correct questions…. It gives me confidence in my questions I’m asking and confidence in being the person asking the questions.”
- Information Literacy: “I think that it makes it helpful for me to find actual resources that are backed up by actual research and then it helps me appreciate the research that I look up.”

Career path. Mentees also identified ways that mentoring supported their career path. One mentee reported, “I have gained more grounding confidence in what I want to do with my degree.” Another stated:

Research mentorship has completely changed how I want to go through my career. I want to do something that is more experimental rather than just waking up and doing the same thing every day. I want to do more research opportunities in my degree and even in my graduate coursework.

STEM identity has been linked to stronger academic performance (Seyranian et al., 2018) and degree persistence (Hughes et al., 2007). Some evidence emerged in this interview that suggested virtual research mentoring improved persistence and attitudes, though it is unclear if this emerged through improvements to STEM identity.

Interestingly, a previous study reported that, while participation in undergraduate research increased STEM degree persistence, mentorship was shown to *reduce* persistence in STEM majors (Chang et al., 2014). These findings could be a result of the mentor helping the student explore their interests and providing a space for reflection on STEM identity, the fit of the field, and career aspirations. This highlights the importance of mentorship in helping students make informed decisions about their career paths. We saw evidence of this phenomenon in our interview results, with one mentee stating:

I realized that I'm never going to be an engineer. Like this is not going to happen. That actually kind of helped me understand what I'm good at and what sparks my interest. You know there was this like dream of being an aerodynamicist like 5 or 6 years ago. But I've come to realize that this is this is so much better for who I am. So

[mentorship] helped me realize which way is like, quote unquote the right way.

While positive outcomes were seen in this study, it is important to note that mentors may need to undertake specific preparation to best help their mentees negotiate personal and professional identities (Hunt et al., 2015).

Resume Building. Two mentees reported a benefit of resume-building, but one response may be interpreted as focusing on undergraduate research engagement broadly rather than the mentoring experiences. The mentee stated, “I was interested to get some sort of anything on my resume so being able to volunteer for a research program seemed a pretty good look.” The other mentee directly addressed the connection with mentoring, stating “[My mentor] helps with … how to incorporate this project on my resume.” There is little attention in the research literature on how research mentors may support students' resume-building efforts. The emergent themes related to professional development were consistent with best practices for active mentorship to develop researcher identity.

Continuous Growth

Self-Efficacy. Mentees reported several ways in which research mentoring generally supported their self-efficacy regarding research. Three mentees specifically explored their low self-efficacy at the start. One mentee shared:

So there's one thing she like plain face is just like ‘you should do this’, and I'm just like ‘That's really cool, but, like, it's totally out of my league, right?’. But she's like, ‘No, you can totally do it.’. So, I think it's like her ability to teach me how to just do things without like thinking I'm not, you know, capable of doing it because of my age, or my degree, or wealth, or whatever it is.

Another mentee reported similar hesitancies that their mentor helped them navigate, stating “I was very nervous, and I didn’t really know what to expect. And I think that I’m much more comfortable now I went into it.”. One mentee disclosed:

And I just sometimes feel like [I] was lost, and I was afraid to ask questions, and that was my biggest downfall and challenge because [I] have a fear of failure and I didn’t want to admit my ignorance on some topics. But, in order to defeat that pride and jump over that hoop, I learned to ask questions [of my mentor].

Another mentee shared a forward-looking confidence, stating “I think I apply for more opportunities without, you know with less fear.” The development of mentee self-efficacy speaks to the mentor's role in providing personal and emotional support.

Lifelong Learning. Mentee responses also spoke to how mentoring expanded their drive for lifelong learning. One mentee shared how learning of mentored research opportunities struck them, saying:

I don’t think it ever crossed my mind that there would be any opportunity for, you know, for any type of research whatsoever. So, when I got an email saying that there was an opportunity, I was very excited about that. Just the opportunity to learn and to be involved with it, I think keeps me going.

Another shared how mentorship has supported their progress toward advanced degree completion, stating “A year ago I questioned if I even wanted to get a master’s degree.” Another mentee shared, “I think that being part of the program just makes me desire to learn more about [STEM] in general.”

Limitations

Sample Size and Generalizability

The small sample size restricts the generalizability of our findings beyond the program under study. The use of interviews, while providing valuable insights, might have deterred participation due to time commitments, further limiting the same size. Nevertheless, this approach allowed for the collection of nuanced information to inform future investigations into the impacts and effectiveness of virtual undergraduate research mentoring models. Meta-themes (first-level codes) can be reliably identified with very few interviews, with saturation (where no new information is observed) occurring for second-level codes at twelve interviews (Guest et al., 2006). As participation in the program grows, we can revisit the coding scheme to ensure saturation.

Demographic and Learner Characteristics

Demographic and learner characteristic variables may influence results. Research on self-efficacy in undergraduate STEM students has shown trends based on gender and degree progress (Concannon & Barrow, 2009). Similarly, STEM identity may be influenced by demographic and learner characteristics (Dou & Cian, 2022).

Interview Format

The format of prescribed questions used in the interview ensured consistency but may have limited our ability to explore unexpected or insightful lines of inquiry and ask clarifying questions. Much of the existing research evaluating research mentoring shares limitations with this study, including lack of control or comparison groups, reliance on self-reported data, lack of direct measures, and measurement over a short period (Gershenfeld, 2014; Linn et al., 2015).

Conclusion

Successful mentor-mentee relationships produce mentees with personal and professional skills, knowledge, and confidence necessary to meet career and professional goals. This study offers initial evidence of the effectiveness of virtual mentoring for fully online undergraduate researchers across these dimensions. identifying four key themes for student benefits: 1) integration into a learning community, 2) enhanced understanding of research processes, 3) professional development, and 4) continuous personal growth. Virtual mentorship participants reported growth in transferable skills including time management, communication, and information literacy skills. All mentees reported improvements in self-efficacy. Notably, several mentees reported significant shifts in their career trajectories due to their participation in undergraduate research mentoring.

This work lends support to the growing body of work in support of a theoretical framework for undergraduate research mentoring which connects self-efficacy, career goals, learning experiences, and career planning. Future work will use qualitative measures to evaluate research mentors' skills in this virtual mentoring program using parallel measures of mentors and mentees as well as direct measures to address the limitations of self-reporting in online environments. Offering a mechanism for evaluating virtual mentorship is important because these types of virtual mentorship opportunities for students are likely to grow over time and effective mentorship of undergraduate research is a growing requirement for the promotion of faculty at many higher education institutions (Della Corte et al., 2022).

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Appendix I

1. What motivated you to join the mentoring program?
2. How has the relationship evolved since you first connected with your mentor?
3. What has surprised you about the experience so far?
4. And what has been your biggest challenge in the process?

5. What are you doing differently because of the mentoring program?
6. What motivates you to continue with the mentoring program?
7. In what ways has undergraduate research mentoring made affected your confidence that you can succeed in advanced coursework in your chosen field's curriculum?
8. In what ways has undergraduate research mentoring affected your confidence that you can complete your degree requirements at this institution?
9. When do you feel comfortable approaching your research mentor to get assistance?
10. How has engaging with undergraduate research impacted your interest in learning STEM?
11. In what ways has engaging in undergraduate research influenced your perspective of yourself as a STEM person and how others perceive you as a STEM person.