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Application of the Salient Practices Framework for Undergraduate Research Mentoring in Virtual Environments

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Undergraduate research is an excellent example of student engagement that leads to numerous benefits for the student and faculty. However, for students to gain the most from the experience, high-quality mentorship is needed. This article introduces readers to the Salient Practices framework, which is based on a comprehensive review of the research on undergraduate research mentorship as well as models of mentoring applied to the undergraduate research context. This article outlines how a group of faculty applied a mentor constellation model and adapted the Salient Practices framework to the virtual environment that resulted from COVID-19, creating a rich professional development experience for all participants. Lessons learned from initial efforts to mentoring in the virtual environment are also discussed. Implementation of mentoring in a virtual context opens up opportunities for increased access and broadening of research teams and mentoring constellations.

INTRODUCTION

There are a number of known benefits associated with participation in undergraduate research (UR) (1–4), including (i) personal and professional gains; (ii) thinking and working like a scientist; (iii) becoming a scientist; (iv) acquisition of relatable skills; (v) enhanced preparation for career and graduate school; and (vi) clarification and confirmation of career and educational goals (2). To help achieve these gains, high-quality mentoring is essential for students (5–7), especially in a UR context, where students are often inexperienced with technical skills and may differ in their backgrounds of foundational coursework in the discipline. At our institution, we use a definition that puts mentoring at the forefront of UR:

> Undergraduate Research and Creative Endeavors include activities undertaken by an undergraduate student with significant faculty mentoring that: 1) Lead to new scholarly insights and/or creation of new works; 2) Add to the discipline; and 3) Involve critical analysis of the process and/or outcome of the activities (8).

Knowing the importance of high-quality mentorship to be crucial to not only the success of the project but additionally to the development of the student, it would be helpful to know what practices mentors should employ. In an effort to provide high-quality mentoring for students, our department, as well as others at our institution, have incorporated the Salient Practices (SP) framework Shanahan and colleagues extrapolated and synthesized from a comprehensive review of the literature on UR mentoring (5). These 10 practices begin with strategic preplanning (SP 1) and end with dissemination of findings (SP 10), but they do not necessarily have to occur in a linear manner through the mentoring process, and each practice frequently needs to be reassessed to meet the needs of the student. See Table 1 for a complete list of the SPs. Implementation of these practices is important in providing high-quality mentoring for the UR students and can be made more difficult when it cannot occur in common environments (e.g., office or lab).

As our university and others went virtual as a response to COVID-19, our department started discussions about how we could mentor UR remotely for both the current semester and upcoming summer research experiences. During these discussions, our department started thinking about the challenges that would be faced by mentoring remotely and how to best meet the needs of the students through the implementation of the SP framework. The specific challenges that we identified included: managing the changing nature of research projects due to the inability to access labs or work safely with human participants (SP 1); the importance of students feeling included and supported despite being away from their mentors (SP 4); and helping students grow professionally as scientists and scholars by being part of a research community (SPs 5, 8, and 9). Many of these challenges are consistent with SPs that have been

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TABLE 1.
SP framework in action within virtual environments.

Practice	Description
Practice 1: Strategically plan to meet varying needs and abilities of students	Group: Cocreate summer schedule (e.g., student-led journal club and faculty-led professional development) Individual: Cocreate summer goals; set weekly meeting times; modify project(s) to virtual context
Practice 2: Set clear, scaffolded expectations	Group: Identify expectations and goals as a group Individual: Identify summer goals and work backwards to plan; discuss long-term goals and how summer experience fits in; collaborate on needs to meet specific goals (e.g., data collection)
Practice 3: Teach the necessary research methods for the discipline	Group: Highlight common topics that apply to human subject research (e.g., survey design, participant recruitment); provide guidance and feedback on best practices for creating and adapting research protocols during COVID Individual: Use tutorials and self-recorded videos to demonstrate techniques or learn skills; be available to students to troubleshoot survey and interview techniques (video calls, text, phone)
Practice 4: Balance high expectations with emotional support	Group: Find space to talk about challenges, both personal and research-specific; optional student-run book club around Diversity, Equity and Inclusion issues Individual: Allow extra time to talk about nonresearch struggles and successes; discuss student needs and interests outside of research (e.g., work, COVID, volunteer, career); integrate time for personal interests and down time while balancing realistic research goals; holistic development and mentoring
Practice 5: Build a sense of community	Group: Meet multiple times a week with different faculty leaders; create a student GroupME chat to ask questions and support each other; opt in for book discussion Individual: Some research teams have comentors, so community is developed during individual meeting times; peer-mentored assignments and grouping students with varying knowledge, skills, and attitudes
Practice 6: Importance of one-to-one mentoring	Group: Create a climate where students feel empowered to go to different faculty for different support needs Individual: Mentor and comentors meet with each student for a minimum of 30 to 60 min weekly to meet the needs of each individual student and project as well as personal counseling and career coaching
Practice 7: Increase student ownership of the summer	Group: Students increase their leadership of group meetings over time and lead peer-review sessions Individual: Transition from faculty-led to student-led meetings; transition from assigned work to students identifying progress reports and goals for following week; students develop their own project schedules and timelines
Practice 8: Support professional development of the students	Group: Weekly professional development sessions with rotating faculty leaders; invitation of graduates and alumni to share professional experiences Individual: Share disciplinary development opportunities (e.g., webinars, conferences, or online panels); provide opportunities to interact with professionals in the field in online presentations
Practice 9: Create opportunities for students to learn mentoring skills	Group: Students lead journal clubs and virtual events of interest; facilitate peer review of writing Individual: Students identify potential future directions and mentees for their research with the possibility to manage their introduction to the research project and process; peer-mentoring of junior students by senior students, such as paired writing, peer–peer methodological training, etc.
Practice 10: Support students to disseminate their research findings	Group: Prepare for poster session required as capstone of summer undergraduate experience; weekly journal clubs and writing sessions Individual: Set goals toward manuscript development and presentation preparation; write a blog post or a magazine or news article to disseminate research to reach broader audiences

See https://www.centerforengagedlearning.org/salientpractices/ for other information about the framework.

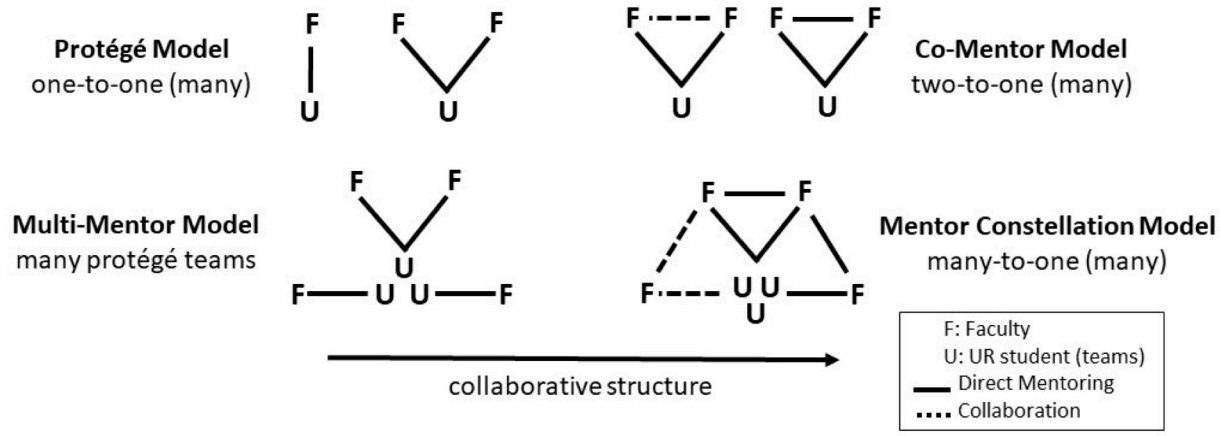

FIGURE 1. Models of mentoring.

found to be challenging generally by mentors (7). In our discussions, it became clear that our strength would be in individual mentoring (SP 6), as well as mentoring as a group or comentoring, using a mentor constellation model (9). We also believed that this would be an opportunity to help give students more ownership of the project (SP 7) faster than would have typically happened under normal circumstances (10) and that technology could be a useful tool and challenge in this (11). The rest of the paper will discuss the importance of various models of mentoring, the implementation of the SP framework for UR mentoring, and what was learned from our initial efforts at remote mentoring.

MODELS OF MENTORING

Integration of the SP framework in the UR context can be facilitated by many mentoring structures. There has been significant work highlighting the importance of a mentored experience in student learning, engagement, and success (12, 13) and a more recent focus on the reciprocity of a mentored relationship in professional development and positive long-term outcomes (14). The most common mentor model is the protégé model (Fig. 1), where an experienced faculty member mentors a student or students on a project, or multiple faculty separately contribute expertise to a student project (15). Another common structure is a multimentor model (Fig. 1), where multiple faculty are involved in a larger project, but individual students typically each still have a single mentor or supervisor and bring together multiple protégé teams (15). While multimentor models are common in science and grant-funded projects, the role of parallel mentors is not recognized or valued as such, primarily because the structures of compensation in higher education assume a protégé model (3, 16, 17). Research examining who contributes to both the project and the development of the UR scholar demonstrates that there are far more players in the mentored experience than are formally recognized (17). This informal multimentoring model can be problematic from a compensation standpoint, but more importantly, it often puts students at the center of managing the multiple mentors which, developmentally, is inappropriate. A formal recognition and intentional collaboration of the multiple mentors, either as a comentor model or mentor constellation model (Fig. 1), can have positive impacts on project, student, and faculty development and outcomes across research contexts (9, 15, 18, 19). A comentored or mentor constellation structure is a collaborative and simultaneous mentoring of a student by two or more mentors. The key activities and characteristics of a comentor or mentoring constellation model are power sharing, turn taking, coleading, dialogue, constructive feedback, transparency, and authenticity (9, 15, 18). This model provides students and faculty consistent engagement with multiple perspectives and lines of expertise, flattening power structures and amplifying collaboration, collegiality, and development (9, 15, 18). Our group decided that we would make intentional efforts to provide comentored experiences for our students to rely on the strengths of the individual faculty members and to help meet the needs of the students.

IMPLEMENTING THE SP FRAMEWORK

The examples provided below are ways in which our department faculty implemented the SP framework in our university's summer UR program. Our university is a primarily undergraduate teaching institution (some professional graduate programs). This program is a 9-week mentored experience where mentors and students are paid a small stipend to conduct research, and it culminates with a half-day of poster presentations. Our department had six students and six mentors (or comentors) engaged in research projects. Three additional faculty from the department helped facilitate the summer program and comentoring of students during this time. Additionally, some of the faculty had other students conducting research over the summer and they were invited to attend all virtual sessions, but these students

were less engaged. The six students were asked to engage in three weekly sessions with other students and faculty. This included journal club (Mondays, 1 hour), writing time (Wednesdays, 2 hours), and professional development time (Thursdays, 1 hour). The students and mentors also met weekly or multiple times per week to discuss their individual projects. The amount of time varied depending on the stage and needs of the project.

Adapting to meet needs and developing resilience

As faculty mentors, we were being asked to provide our mentees with an active and engaging learning experience through our summer UR program. Early on, it was identified that some research projects had to be halted or reimagined because of the inability to work on campus together (see Table 2 for several examples). This reimagining of projects required a great amount of strategic preplanning (SP 1) and determining new goals (SP 2), allowing for a deeper focus on the research process itself instead of focusing on a product (e.g., paper or presentation). The approaches chosen by some mentors supported a continued student learning environment by encouraging novel applications of knowledge and skills learned previously or facilitating student acquisition of new skills and techniques to carry out their research (SP 3). Students analyzed existing data sets, were asked to rethink prior analysis plans and, in some cases, pursue new questions. Others chose to redesign current projects by implementing virtual laboratory sessions, modifying data collection, simplifying testing procedures, and using technological devices and computer software. Therefore, redesigned research projects provided students with opportunities to develop nontraditional laboratory skills, apply critical thinking and problem-solving strategies, and use modern technology. The technological literacy gained from these experiences will be a valuable skill for mentees and may help faculty upscale their research mentoring. Adapting to the variety and depth of challenges created opportunities to practice resilience individually and as a community of scholars.

Importance of individual meeting check-ins

Checking in with student mentees is central to effective UR mentoring. Many of the SPs identified by Shanahan and colleagues infer a one-on-one, individual interaction (5). The value of hands-on mentoring has been reported for two decades (20, 21), with outcomes suggesting that students value the emotive and relational components (SP 4) of mentored research more than other aspects (20), and student learning and time spent with their mentor are strongly related (21). However, physical interactions were difficult due to the remote environment, though the need was great. For example, with research projects requiring modification to address the problem of data collection with human subjects, new strategic preplanning (SP 1) was necessary, along with establishing new expectations (SP 2).

Given the added stress and cognitive load associated with the move to virtual mentorship, deeper collaboration between the mentor and student researcher became essential for an effective mentoring relationship to be nurtured (SP 6). To maintain this valuable component of the research experience, mentoring dyads first worked together to come up with a weekly schedule that included at least a single individual meeting each week. These were done via video conferencing and began with a listening session during which the mentees were encouraged to share what was most salient for them at that moment. Mentors sought to validate what students were feeling, rather than trying to provide solutions. They set the stage for this type of interaction by patiently accepting the student's home environment during their meeting time, including the interruptions from dogs, siblings, and unstable internet connections. Mentors shared their home environments as well, fostering a greater level of openness and, perhaps equity, with their students. The empathetic nature of these meetings enabled the development of realistic expectations on both sides that reflected the level of stress and cognitive load each was experiencing. More casual check-ins also occurred via e-mail, text messaging, and as part of other activities, including mentored group writing times and student professional development sessions. These informal interactions enabled significant emotional support from mentors and growth in student confidence and ownership of their projects (SP 7).

Creating a community of scholars

Though the mentored relationship is the cornerstone of successful UR, of similar importance is the ability to supplement that relationship by integrating mentoring teams into a community of scholars. This community contributes to a high-quality experience in which students feel emotionally and academically supported (SP 4), and the mentoring constellation is expanded beyond the direct project itself into the development of a young scholar (SP 5). The importance of building a community of scholars is inherent in several of the SPs of UR (5). For example, SP 5, Building Community Among Members of the Team, highlights the importance of mentoring relationships built through collaborative scientific activities (5). Similarly, the SP framework's practice 3 (teaching technical skills), 4 (emotional support), 8 (professional development), and 9 (learn mentoring skills) describe aspects of mentorship that are best implemented in the context of a scholarly community. In a typical in-person context, these practices can be implemented in many ways, with literature describing models such as the mentor demonstration model and community mentoring models (22–24). However, during a time of crisis, the needs and responsibilities of mentees and community members change, such that modifications must be made in order to foster an ongoing community.

TABLE 2.
Examples of challenges and modifications.

Project 1: The Effects of Tart Cherry Juice and Protein on Muscle Recovery and Muscle Soreness after Exercise-Induced Muscle Damage (EIMD)	
Project Description	The original goal of this multimentored, double-blind, randomized controlled trial was to complete a 7-day supplement vs. placebo intervention following a fatiguing exercise routine. Proposed testing included seven in-person visits. Data collection included psychological and physiological assessments in the laboratory. The student was responsible for advertisement, participant recruitment, and data collection.
Challenges Faced	The student was not present on campus during summer due to COVID-19 restrictions. It was not feasible to continue project development for in-person laboratory visits. The IRB had to be modified to include and maintain COVID-19 safety measures for equipment cleaning and shipping. We had to adapt to virtual mentor–mentee meetings, participant recruitment, and data collection. Additional costs were incurred due to shipping and individual equipment purchased.
Modifications Made	Project goals remained similar, with a few modifications, including virtual testing sessions, smaller sample size, shorter intervention, and fewer measurements collected. An increased number of sessions and an on-line presence provided an opportunity for the student to continue developing written and oral communication, leadership, and organizational skills, take ownership of the project, and cultivate self-motivation. Other modifications included virtual data collection using Zoom and Qualtrics Survey Software, which allowed the student to learn new data collection, organization, and analysis skills. Moreover, the student attended virtual journal club and peer mentorship meetings to facilitate personal and professional development.
Project 2: Behavior Change Trajectories and Metabolic Syndrome Risk Factor Clustering during the Transition to College: a Pilot Study	
Project Description	This protégé-mentored longitudinal project originally aimed to recruit a new wave of participants and to complete follow-up testing of those participants already enrolled. Testing included two in-person visits, during which time participants underwent a range of cardiometabolic and behavioral assessments. Thus, the student's main charge was to coordinate recruitment and data collection throughout the semester.
Challenges Faced	In-person research was halted due to limitations imposed by our institution's IRB on studies that included "high-risk" measures or patient populations (e.g., close, in-person contact with measures such as venous phlebotomy). Similarly, students were required to leave campus to quarantine at their homes. Thus, the major challenge was to continue the student's personal and project development without the opportunity to finish collecting their data or benefit from in-person mentoring.
Modifications Made	Project goals were reframed to focus on answering the original research question using data already collected. This provided the student–mentor dyad with the opportunity to develop new statistical analysis skills to overcome the shortfall in data. Subsequently, the student was encouraged to take ownership of the new direction of their project by identifying an undergraduate research journal in which their work would best fit and to focus on the dissemination of their findings. Other modifications included more frequent, virtual check-ins throughout the writing process to support the student both technically and relationally. Moreover, the student was engaged in peer-mentoring by virtually mentoring junior students in the advisor's lab through aspects of the research process that they had experience in (e.g., developing a research question, drafting an IRB, writing, and teaching technical skills).
Project 3: Good Food, Good Mood: Relationship between Nutrition and Mental Health in Elite Athletes	
Project Description	The original goal of this internationally comentored project was to travel to the UK to understand the perspectives and practices of coaches, sports medicine staff, and athletes within a professional soccer organization about knowledge, application, and integration of nutrition and mental health.
Challenges Faced	Travel was shut down, and the logistics of completing and mentoring this international program remotely challenged us to think about the main goals and more feasible routes to achieving meaningful outcomes.
Modifications Made	The project was adapted to an Elon-based comentored project focusing on US-based collegiate programs and took a more informational interview approach to understand knowledge, organizational structure, resources, and application of nutrition and mental health.

Key challenges faced during a time of crisis include (i) the need for heightened social–emotional support, given the stress of the situation and relative social isolation, (ii) an inability to perform many preplanned research activities or the requirement to shift these activities online, and (iii) differing schedules and time zones among community members, as well as potential technological issues leading to difficulty with synchronous activities. Several ways in which we modified our mentorship to develop a community of scholars, whilst implementing the aforementioned SPs in a modified online context, included virtual journal clubs and professional development sessions (with faculty from in-house as well as other institutions), and structured peer mentoring. First, virtual journal clubs were held on a weekly basis, providing students with the opportunity to discuss research similar to their own and to broaden content knowledge through discussion of peers' research. These further helped foster a balance in scholarly expectations with social–emotional support as students were able to connect with faculty other than their mentor, as well as other students experiencing the same situation. Second, virtual professional development sessions (e.g., discussion of transferability of research skills to jobs or grad schools and ways to better present research data (see Table 3 for greater detail about these sessions), whilst providing the aforementioned opportunities, allowed students to network with faculty other than their mentor. Such opportunities are arguably easier to foster given the online environment and negated need for travel and can be recorded for asynchronous delivery to allow for flexibility in schedules. Finally, structured peer mentoring (i.e., senior students virtually mentoring junior students through technical aspects or writing assignments) was used as a cross-cutting technique that provided several opportunities to build cohesion among UR students, while facilitating further learning through teaching. Few of the aforementioned strategies would have been feasible had the appropriate infrastructure not been in place, specifically, collaborative software (e.g., such as Zoom, Google Apps, WebEx). Such online conferencing tools have shown promise facilitating the creation of educational communities and mediation of critical reflection and discourse in our experiences and those of others (25).

Lessons learned

The short-term lessons learned were derived from student feedback, provided by two members of the cohort who had previously participated in the program. We informally gathered their perspectives, which will be useful in improving the experience in upcoming iterations whether on campus, remote, or a hybrid structure. Students identified challenges in building community, especially with each other, and suggested more time spent developing community or fostering more opportunities to do so even before the experience starts. They felt the online format did not provide the same level of a community of scholars among students compared with the on-campus experience. The challenge of getting to know each other impacted opportunities for unstructured peer review of writing and social interactions, both of which were highlights of the on-campus structure. They did however find the online format required them to be more self-motivated, adaptable, and creative, and they highlighted that this fostered greater resilience and self-confidence as scholars.

Additionally, through these experiences, which we have been engaged in as a department in some capacity for over a decade, we have some longer-view perspectives of lessons learned. We as individual scholars and as a community of scholars have learned from and with each other, with the most profound and sustained outcome of this community and mentoring constellation being a democratization of the UR experience (11). We as a whole learn from each other as mentors and scholars, as well as from students committed to their projects and to their development. As an extension, we trust that decisions and ideas are better when we share responsibilities and let leadership move among us. These community outcomes have in many ways been amplified in the virtual context and given us a more flexible model for inclusion of voices which can be essentially anywhere, expanding our mentoring constellation opportunities.

In addition to the community benefits, there are targeted benefits to both faculty and students. The benefits for faculty include professional development as teachers, mentors, and scholars, challenging each other by having more perspectives included in project development; a built-in structure that affords each of us to see mentoring occur in vivo; and colleagues who can support students and faculty in their professional development journey (18, 26). Because of the structure we have created as a department, there are informal formative opportunities for all of us, which lead to better understanding of each other's work, our individual and shared strengths, and an ethos of collaboration and genuine support. For students, the benefits often are recognized far beyond their time as an undergraduate as they learn how to become engaged and collaborative colleagues. Students not only watch the faculty discuss, question, challenge, and support, but also they learn that their voice and perspective are respected and heard in that space. The ability to practice being a scholar and a professional with more seasoned scholars sets them up for success in the many fields and career paths they pursue. The skills and characteristics they learn in their UR experience have been identified by employers to be key to the applicants they recruit and hire (27). These skills and characteristics are both deepened and amplified because of the community and mentoring constellation we have supported in our program (9, 28).

CONCLUSION

Finally, this experience has broadened our vision of mentoring and mentoring constellations to further expand

TABLE 3.
Examples of professional development sessions.

Session Title	General Description
"Communicating Research and Scholarship"	Session Aim(s): The aim of this faculty-led Zoom session was to open a dialogue among students regarding the importance of communicating their research and to expose them to the benefits and barriers associated with research dissemination across several media. Topics Covered: Topics included a) the importance of dissemination of research; b) typical modes of scholarship communication; c) problems and pitfalls associated with the communication of research; d) media misconceptions; and e) guidance for communicating scholarship via oral presentation, poster presentation, and written communications (e.g., abstracts). Student Experience: Students were engaged throughout the session with think–pair–share and "shout-out" activities, other faculty were called upon to give input on their experiences, students completed a social media–based activity to help them identify their audience and consider how to communicate their research to a lay audience, and the session culminated with the provision of useful resources related to the topic.
"Transferable Skills Learned from Undergraduate Research for Future Employment and Grad School"	Session Aim(s): To discuss with students the importance of the skills learned in undergraduate research and how they are of importance to future employers and graduate schools. Topics Covered: Students were asked to read the 2015 report created by Hart Research Associates titled "Falling Short? College Learning and Student Success." After the final discussion on the topic, students were asked to do some reflective writing where they were given the 15 most important college learning outcomes (e.g., the ability to effectively communicate orally) and write whether or not their undergraduate research experience developed these and give examples if so. Student Experience: The students felt that undergraduate research was successful in developing most of the skills employers were interested in. This session also helped students think about the stories they could tell employers about their research experience and through personal statements to show their growth from participating in undergraduate research.
"Diverse representation in Health-Related Research: Responsibility, Opportunity, and Impact"	Session Aim(s): Our summer research experience coincided with amplified events around police brutality, racism, and Black Lives Matter protests. Collectively our faculty and students wanted to engage in conversations and professional development around diversity, equity, and inclusion. Topics Covered: 1) diversity representation in exercise/health science research; 2) social and biological identities and the importance for representation in a breadth of categories (race, gender, sex, disability); 3) populations historically missing from health-related research; 4) realities and challenges of human subject recruitment; and 5) necessity to prioritize representation as scholars and developing scholars. Student Experience: Students and faculty engaged in a group discussion about ideals and realities. We discussed strategies for recruitment and the impact of our primary strategy of convenience and snowball sampling. This conversation threaded throughout the experience as students would often identify gaps in recruitment and the impact on the interpretation of results. We collectively engaged in informal check-ins, and a group of students and faculty opted into a book club to discuss antiracism topics across several weeks. These conversations collectively fostered meaningful connections and conversations among the group and provided ongoing opportunities for personal, professional, and field-specific development.

access and expertise. As we look to the future, we will incorporate a virtual component even if we are able to work on our physical campus. For example, virtual alumni and conference events with larger audiences, research recruitment and implementation including larger and more diverse communities, use of new technology and software for data collection, analysis, and dissemination of research findings, as well as national and international collaborations with colleagues from across the world. The added ability to include students who may have opportunities or responsibilities that do not allow them to be on campus, as well as seamlessly incorporating alumni and colleagues at other institutions or abroad in professional development components, is something that will continue to strengthen and support our UR program.

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