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Postdoctoral insights on mentoring excellence: a framework for best practices at Sandia National Labs

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ABSTRACT

The Sandia National Laboratories Strategic Plan FY24-FY27, updated for FY25, outlines Sandia's two Big Labs-wide Goals, Accelerate Innovation and Lead in Modern Engineering. The goal of Accelerate Innovation is that "by FY27, Sandia will be a leader in scientific, engineering and operational innovation and an employer of choice for highly innovative and creative talent." Sandia's postdocs are leaders in innovation, well-versed in emerging techniques and cutting-edge methods, and capable of acting as a highly agile technical force across domains at the lab. As a federally funded research and development center (FFRDC), Sandia National Laboratories attracts top doctoral talent by offering a unique opportunity for postdoctoral researchers to develop at the crossroads of government, academia, and industry, working in multi-disciplinary teams and performing cutting-edge, mission-specific research that responds to immediate needs of national interest. However, this creates unique opportunities and demands of both postdoctoral appointees and the Sandia staff who act as their mentors, making mentorship key to attract talent. Since 2007 the Sandia Postdoctoral Development (SPD) Board, originally Postdoc To Professional (PD2P), a networking group at Sandia composed of a voluntary board of current postdocs and two staff liaisons, has advocated for postdoctoral development within Sandia National Labs. In this white paper, SPD board members and the Sandia Postdoctoral Development Office, organized in 2019, have come together to develop a comprehensive overview of the postdoctoral mentoring landscape at Sandia National Labs as we currently know it. By scouring various forms of data from efforts since 2018, we've compiled a community-derived perspective on what makes postdoctoral mentorship at Sandia unique. First, we analyze working sessions held between mentors and mentees to develop a comprehensive map of who is involved in postdoctoral mentorship at the lab and how the responsibilities are divided amongst mentors and mentees. We then combine multiple forms of data, including exit surveys, annual surveys, and community workshops, to identify the specific challenges that mentors and mentees encounter at the national lab. Finally, we use text mining and sentiment analysis to analyze mentoring award data to develop an idea of what postdocs are self-identifying as excellent mentorship within the lab. It is our goal that this white paper act as an ongoing resource to the postdoc and postdoc mentoring communities and provide a firm foundation for further conversations on the future of postdoctoral mentorship at Sandia National Labs.

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EXECUTIVE SUMMARY

The Sandia National Laboratories Strategic Plan FY24-FY27, updated for FY25, outlines Sandia's two Big Labs-wide Goals, Accelerate Innovation and Lead in Modern Engineering. The goal of Accelerate Innovation is that "by FY27, Sandia will be a leader in scientific, engineering and operational innovation and an employer of choice for highly innovative and creative talent." Sandia's postdocs play a crucial role in this innovation, as demonstrated by their involvement in numerous LDRD projects that push the boundaries of scientific and engineering research. Enhanced mentoring of scientific trainees, such as postdocs, fosters more creative research outcomes and cultivates a sense of belonging within the workplace culture.

Since 2013, the Sandia Postdoctoral Development (SPD) Board—a voluntary group of postdocs and staff liaisons—has advocated for postdoctoral development at Sandia National Labs. Recently, SPD board members and the Sandia Postdoctoral Development Office, established in 2020, collaborated to create a comprehensive overview of the postdoctoral mentoring landscape. By analyzing data from workshops, surveys, and award programs since 2018, we have compiled a community-derived perspective on what makes postdoctoral mentorship at Sandia unique. This effort has identified opportunities for engagement among all stakeholders involved in postdoctoral mentorship and outlines a cooperative roadmap to support evidence-based mentorship practices within the laboratory (Sandia Leadership Team, Center Directors, Senior Managers/L2, Managers/L1, Sandia Postdoctoral Development Board & Postdoctoral Development Office, Mentors/Staff, Mentees/Postdocs).

ACTION ITEMS:

Sandia Leadership Team:

- Ensure alignment of mentoring practices with Sandia's Accelerate Innovation Goal by promoting proven mentoring strategies among leaders and communicate the importance of mentorship in achieving these goals.
- Communicate that participating in proven mentoring practices are a way that Sandia scientists can tie their work to the Accelerate Innovation Goal. This would also align with the Sandia behavior of Connectedness.
- Center Directors:
- Support professional development programming for all employees, inclusive of postdocs
- Include training budget specifically for professional development of postdocs
- Harmonize and communicate division and level expectations for postdocs for their engagement while at Sandia and their future after the postdoc
- Communicate how mentoring aligns with Sandia's Big Goals and aligns with Sandia's behavior of Connectedness
- Reward managers that exemplify mentoring

Senior Manager/L2:

- Recognize and reward Level 1 managers and staff who excel in postdoc mentorship through formal acknowledgment at team meetings or via Sandia employee recognition pathways (Employee Recognition Awards, Kudos, performance reviews, etc.)
- Support professional development programming for all employees, inclusive of postdocs
- Harmonize and communicate division and center level expectations for postdocs for their engagement while at Sandia and their future after the postdoc

- Potentially hold a mentor roundtable discussion quarterly with all staff in the group that have postdocs to facilitate discussion on difficulties mentors may be having and demonstrating your commitment to high quality mentorship

Manager/L1:

- Incorporate dedicated time for mentorship discussions into regular progress meetings, focusing on project progress and skills development opportunities for postdocs
- Discuss project progress and skills development opportunities
- Mediate and manage conflict resolution proactively
- Communicate proper time code charging practices to staff mentors and postdoctoral appointees
- Leverage your network to suggest mentors outside of the group/center to mentees and reach out to the postdoc program office at PostdocOffice@sandia.gov for assistance if needed
- Ensure that mentor understand that participating in mentoring workshops organized by the PDO/PDA is key to their success
- Revisit the funding situation to access that there is full funding for all of the postdocs in your department, communicate any expected changes with mentors and mentees, and work with postdoc and technical mentor to secure additional funding if a project ends unexpectedly

Postdoctoral Development Board & Postdoctoral Development Office:

- Engage with the postdoc community through regular assessments to identify their needs, provide field-nonspecific professional development seminars and networking opportunities, and facilitate cross-group/cross-lab networking opportunities to expand postdoc mentor networks
- Organize updated and regular workshops for mentoring skills development
- Analyze the feasibility mentoring program, making sure that mentors are engaging with the skill development seminars/workshops
- Annual pulse surveys in the postdoctoral community for their satisfaction from their mentors/ needs not covered from their mentors. Write an evaluation report and distribute it to the mentors/ L1s
- Advocate to the L1 level when it comes to bad mentoring practices/ professional abuse
- Offer open mentoring consultation for both mentors and mentees ("if you need any help, send me an email and we have a meeting to discuss it")
- Develop existing career resources and distribute them to mentors to successfully incorporate them into their mentoring

Mentor/Staff:

- Prioritize onboarding resources by communicating them to mentees before their start date when possible, ensuring they are well-prepared for their transition into Sandia
- If having FN postdocs, be fully informed about the onboarding red tape concerning FN, seek out the Foreign National Networking Group (FNNG) and familiarize yourself with the FAQs for Foreign Nationals – Information Systems and Services

- Organize regular mentoring 1:1 meetings (exclusively on mentoring/ career discussions, not current research related)
- Report to L1 about mentoring practices and progress
- Attend the mentoring workshops organized by the PDO/PDA
- Provide feedback to the postdoc regarding their progress against professional development goals

Mentee/Postdoc:

- Seek out multiple mentors to diversify your mentoring network. Attend networking events and reach out to colleagues to identify potential mentors who can provide diverse perspectives.
- Take ownership of your professional development by creating a clear career plan that outlines your goals, skills to develop, and milestones to achieve.
- Regularly discuss your progress and any challenges with your mentors, and don't hesitate to bring up concerns to Level 1 managers, the Postdoc Development Association (PDA), or the Postdoc Office (PDO).
- Attend and engage with mentoring workshops organized by the PDO/PDA to enhance your skills and understanding of effective mentorship practices.
- Be open to feedback

ACRONYMS AND TERMS

Acronym/Term	Definition
SPD	Sandia Postdoctoral Development Association
PDA	Postdoc Association
PDO	Postdoc Office
PD	Postdoc
FFRDC	Federally funded research and development center
Sandia	Sandia National Laboratories
SNL	Sandia National Laboratories

1. ACTIONABLE INSIGHTS

The following goals focus on both immediate and long-term actionable steps that the Sandia Postdoctoral Association and associated stakeholders can take to enhance their professional development and mentoring experiences as well as establish a sustainable framework for postdoctoral mentorship at Sandia. These goals are grounded in a comprehensive analysis of the mentoring landscape, emphasizing the importance of continuous adaptation to meet the evolving needs of postdoctoral researchers.

1.1. Short Term Actionable Insights (next 2 years):

Drawing from *sections 3 and 4*, we suggest encouraging and supporting postdocs to find at least two mentors to both increase the breadth of expertise available to the postdoc and decrease the burden of mentoring on staff and to decrease the chance of conflicts of interest in mentoring relationships. We can also enhance postdoc development and connections within the lab by encouraging and supporting a multi-mentor approach to mentorship, increasing diversity of experience and reducing potential conflict of interests and staff burden associated with sole mentorship relationship. SPD would like to expand their scope to hold additional town hall meetings with the postdoc (PD) community to discuss the pros and cons of this approach, action items for how to find and establish multiple mentoring relationships, as well as expand peer and internal networking opportunities to increase the mentor-mentee pool. This may include key partnerships with the Los Alamos National Laboratory Postdoctoral Development Office, the Los Alamos Postdoc Association, and the Lawrence Livermore National Lab postdoctoral community to identify if best practices from their mentoring program can be applied to Sandia.

1.2. Long Term Actionable Insights (5+ years):

From *section 1* we see that most of the mentoring needs of Sandia PDs are currently addressed with Sandia's core values. SPD proposes expanding these values to include direct support for professional development for postdocs, like a sensitization campaign on proper time billing for postdoctoral appointees, that would benefit other groups associated with postdocs.

It is clear from *section 4* that a postdoctoral appointment at a national lab includes unique considerations for postdoctoral success from both mentors and mentees, in comparison to the considerations in academia. SPD will endeavor to describe these differences and its benefits and consequences on postdoc's long-term success. This will help define where postdocs require additional mentoring from internal and external sources. For example, at a national lab there are limited opportunities for teaching and course development that are critical for securing an academic appointment. For this example, a list of resources can be developed and be provided to postdocs and mentors that fill that need for the postdoc's tenure track faculty application.

Additionally, from *section 5*, the mentoring experience at Sandia is highly variable to the specific division, center, and group of the mentor-mentees. With a postdoc population of consistently over 300+ appointments since 2021, engagement from divisions containing postdocs will be critical to developing robust mentoring standards. SPD will endeavor to work with division leaders, representatives, employee resource and networking groups, and existing lab-wide workplace improvement networks to identify opportunities for mentoring programs that are sustainable at the center level.

2. INTRODUCTION: CURRENT STATE OF POSTDOCTORAL TRAINING AND MENTORSHIP AT SANDIA

A postdoctoral position is an important crossroad in the professional career of an early-stage scientist and researcher. It signals the transition from traineeship to the professional world and comes with increased responsibilities and the expansion of career paths and opportunities. Strong mentorship is critical to guide postdocs during this transition. In general, postdoc mentors are responsible for helping the early career researcher a) evolve from the grad school position towards being an autonomous researcher and project manager, b) develop and expand their relevant skills, both technically and intellectually, c) network successfully in their corresponding fields and increase their name recognition and scientific integrity among their peers and d) decide on their future steps in a diverse and complex professional landscape, all of them in respect to the individuals' personality and personal history.

The abovementioned role of a mentor is being further enriched with specific responsibilities in an environment such as a national laboratory. National labs, at the crossroad of academia and industry, contain multi-disciplinary teams performing cutting-edge, mission-specific research in respondence to immediate needs of national interest. Postdocs who join national labs need to adapt to an environment with more stringent regulations and procedures than the ones they were likely used to. Postdoctoral appointments at national labs can lead to a wider selection of career options after their tenure, with researchers either further specializing in national lab work, or moving into academic, industry, or government. Additionally, foreign nationals who join a national lab must navigate the additional security constraints and options regarding immigration and residency. This makes mentoring postdocs at national labs particularly unique, as mentors are expected to guide the young researchers through onboarding, navigating through the complex bureaucracy of the laboratory, and help them relate to their peers in academia and industry. Postdoc mentors are expected to provide both technical and career. They are often the principal investigator that the postdoc reports to, and so they are playing multiple mentorship roles for the postdoc. The postdoc will also report to a level one manager, separately from their research advisor and/or mentor, which may or may not be the same person. The manager's role is to provide a framework and connection to Sandia's ecosystem as well as resources that they need to perform their work. Given the uniqueness of a postdoctoral position at Sandia, efforts have been made over the past decade to support postdocs and their mentors.

Broadly, Sandia has many optional training opportunities for employees to improve their mentoring skills. In both 2018 and 2024 Sandia enlisted the Center for Improvement of Mentored Experiences in Research (CIMER) to provide workshops on mentoring for Sandia staff members and mentoring up for Sandia postdocs. Additionally, between June of 2024 and July of 2025 the Sandia Postdoctoral Program Office implemented the CIMER mentoring curriculum that was specifically adapted for postdoctoral mentoring experiences at National Laboratories. Several Sandia employees have taken the CIMER facilitator training for the mentoring training program. So far, 20 postdoctoral mentors have gone through the curriculum, a small but significant start considering a postdoc population of around 350. At the corporate level, beyond just mentorship for postdoctoral appointees, Sandia has created the Career Development Office, which includes resources for becoming a mentor and finding a mentor. There are also several training workshops that are available for both mentors and mentees at Sandia, focused on different parts of the labs. Some workshops are specific to business professionals, some to research development of staff members and postdocs, and several others are for general mentoring relationships. Sandia also has a self-driven Peer Mentoring Program, which matches groups of people across the organization together based on shared interests.

Most ongoing efforts involving postdocs and mentors are self-run and self-motivated. Sandia's Postdoc Development Association and Postdoctoral Program Office have both encouraged postdocs to fill out a self-evaluation form, which is shown in Appendix A. The postdoc would fill out the form and then meet and discuss this document with their staff advisor and their Level 1 Manager and work together to determine a path forward for career development. There are many similar self-evaluation forms, sometimes also called Individual Development Plans (IDPs). The Postdoctoral Program Office (PDO) created a digital version of the form in Appendix A, with the goal of having it routed automatically to the staff advisor/mentor and manager, as well as providing an opportunity for the mentor

and manager to provide feedback. Unfortunately, the platform that the system was built on was cumbersome and the PDO was not staffed at a level to be able to handle all the software issues. Several summer internship programs at Sandia have implemented the use of mentoring agreements or mentoring compacts, a more informal, collaborative document focused on mutual understanding and open communication when compared to a mentoring contract. An example of a mentoring compact is shown in Appendix B, and could be implemented for postdocs as well. This compact was adapted from one provided to Sandia by a staff member at the SLAC National Lab who had taken the CIMER facilitator class.

In spring of 2025, during the development of this document, the Sandia Postdoctoral Development Board surveyed the current postdoc population for their attitudes and values for specific components of mentorship. Postdocs were given 19 components of mentorship and asked to rate on scale of 1 to 5 (highest), how important each component is to a mentoring relationship at Sandia. With 36 responses, we see that a lot is expected from mentors. When responding, only 1/36 postdocs said a component was very unimportant (rating of 1) and 5/36 postdocs said a component was unimportant (rating of 2) to them. Meanwhile 33/36 postdocs said that all components were *important* (rating of 4), and the remaining three selected that all components were *very important* (rating of 5). The top 3 most valued components of mentoring (by average response) were: (1) clearly communicates regarding project goals, (2) gives proper credit and attribution for postdoc intellectual contributions, and (3) plans and communicates effectively. The components of mentorship with the most variation in rated value, i.e. with the most potential to vary between postdocs, were: assists postdoc in creating strong networks in the broader scientific community, promotes postdoc activities of publishing in high-impact journals, assists postdoc in creating strong networks to fellow researchers, and recognizes postdoc as a strong technical collaborator.

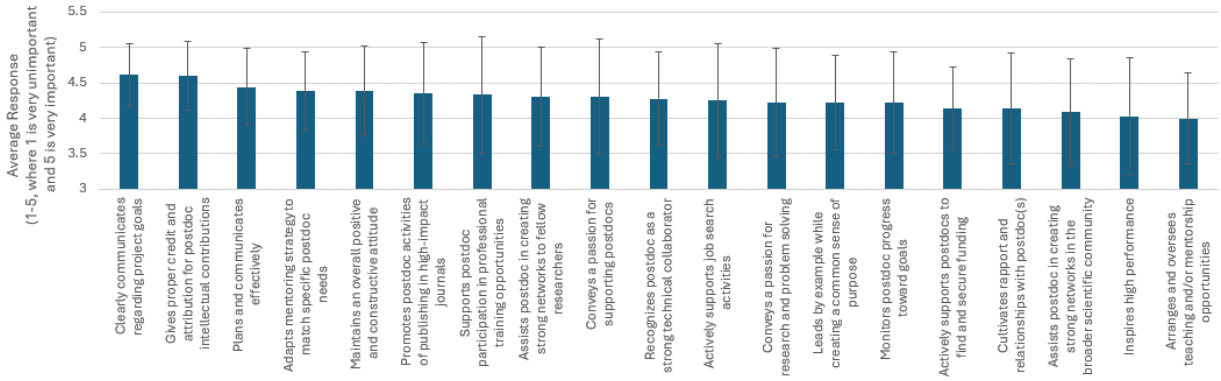


Figure 1. Importance of mentoring components in Sandia postdoc mentor-mentee pairs

Postdocs were then asked to indicate how well, on a scale from 1 to 5 (best), were their mentoring needs being met in their existing mentoring relationships. Responses indicate that mentors convey passion for research and problem solving, maintain an overall positive and constructive attitude, and give proper credit and attribution for postdoc intellectual contributions to projects (top 3 for highest % responding yes to that component). They also indicate that a third or more postdocs have unmet needs for mentors assisting postdocs in creating strong networks in the broader scientific community, in supporting job search activities, such as reviewing application materials, running mock interviews, and providing feedback on job talks, job negotiations, and job prospects, in monitoring postdoc progress toward goals in technical learning, professional development, and career planning, and in arranging and overseeing teaching and/or mentorship opportunities.

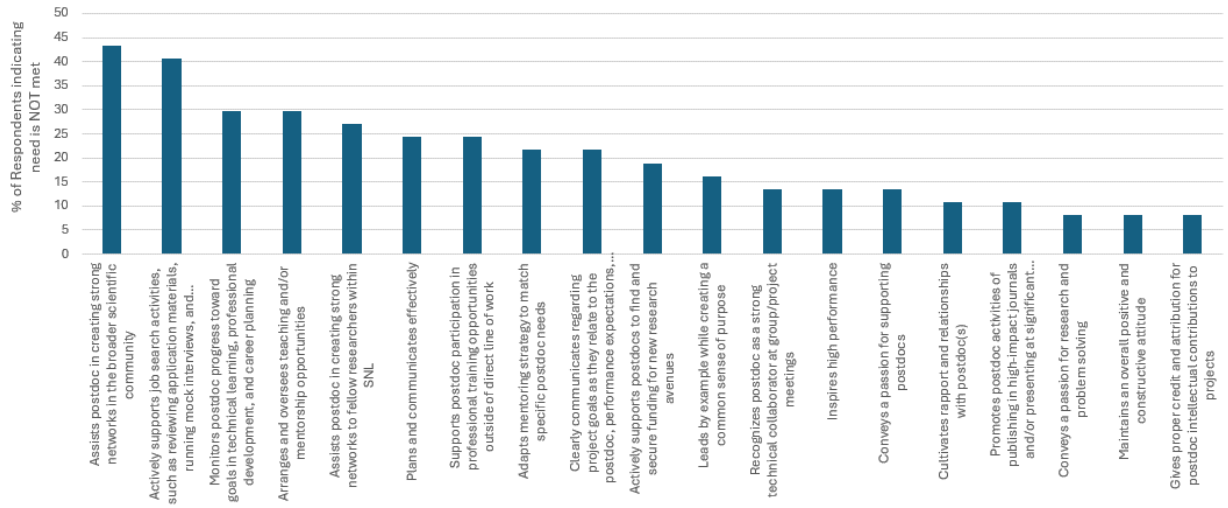


Figure 2. Percent of postdocs stating mentoring need is not currently met in mentoring relationship.

As we reflect on the current state of postdoctoral training and mentoring at Sandia, it becomes evident that the effectiveness of these programs is deeply intertwined with the unique characteristics and diverse backgrounds of the postdoctoral researchers themselves. Understanding who these postdocs are— their demographics, experiences, and aspirations— is crucial for tailoring mentorship and development opportunities that meet their specific needs. In the following section, we will explore the demographics of Sandia postdocs, shedding light on the talent that contributes to the laboratory's mission and innovation.

3. INTRODUCTION: WHO ARE SANDIA POSTDOCS?

The Sandia dictionary defines postdocs as a "temporary non-represented employee who has completed their PhD within the past five years and who is hired to perform Post Doctorial research that is aligned with mission work at the Lab. Term of employment may not exceed a six-year term limit." The National Postdoc Association defines postdocs as: "A postdoctoral scholar ("postdoc") is an individual holding a doctoral degree who is engaged in a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path of his or her choosing." Expectations at Sandia for postdocs vary highly across the lab, with division-level, center-level, and mentor-level culture impacting what it means to be a postdoctoral appointee. Additionally, postdocs may be remote workers or located across any of the Sandia campuses, such as those in Livermore, California and Albuquerque, New Mexico.

The postdoctoral workforce at Sandia has seen significant growth over the years (figure 3), reflecting the laboratory's expanding research initiatives and mission requirements. In 2013, there were 175 postdocs, and this number steadily increased from 2014 to 2018. By 2019, the postdoc population reached 268, and this trajectory persisted, reaching 315 in 2024. The overall trend indicates a robust and expanding postdoctoral community at Sandia and the essential role postdocs play in driving innovation and supporting the laboratory's mission.

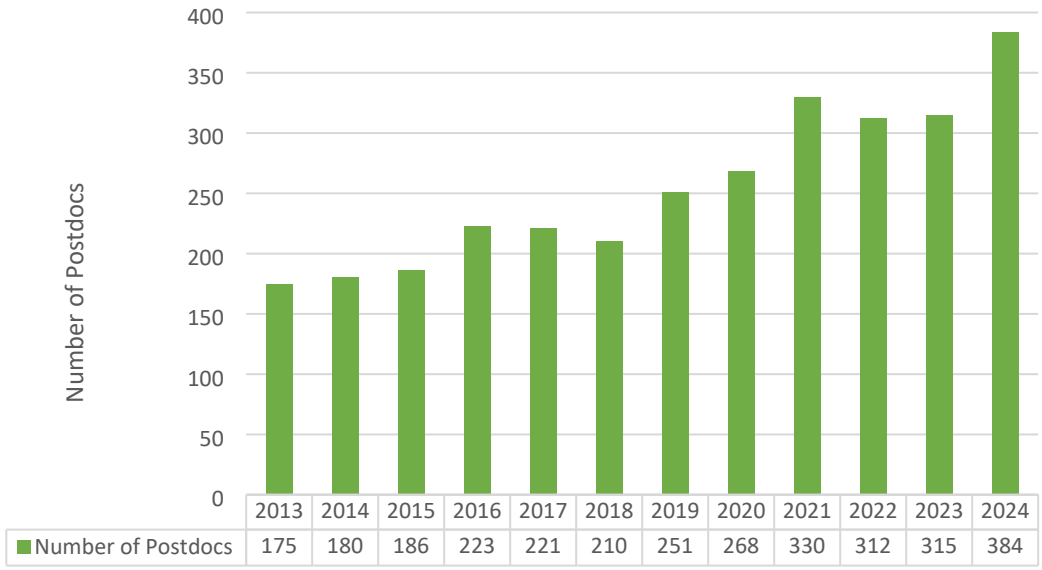


Figure 3. Number of Postdocs Per Fiscal Year, FY13 – FY24

Postdocs at Sandia work in many different technical areas, performing research that ranges from fundamental research to very applied research with immediate impact to Sandia's national security missions. Sandia postdocs come from a diverse array of academic and professional backgrounds, bringing unique perspectives and expertise to their work. Figure 4 outlines degree programs that have at least four postdocs at Sandia.

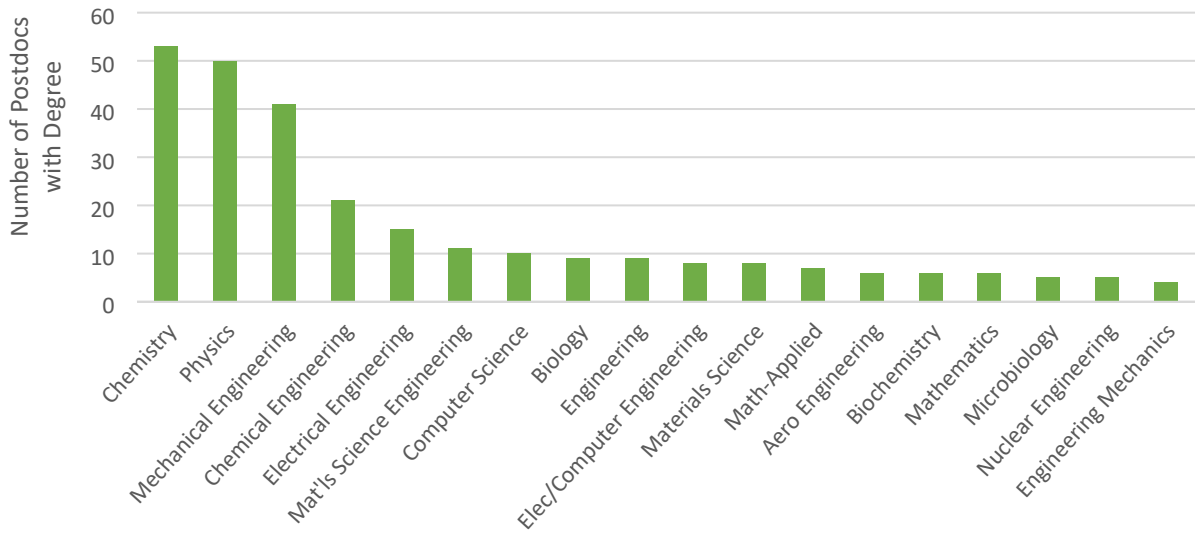


Figure 4. Postdoctoral degree fields with four or more postdocs at Sandia *(data for FY24)*

Some postdocs choose to continue specializing in their specific fields, deepening their knowledge and skills to contribute to cutting-edge research and innovation. Others may opt to diversify their skill sets, engaging in interdisciplinary projects that allow them to apply their expertise to new areas of research and development. This not only enriches the research environment at Sandia but also enhances the adaptability and effectiveness of the postdoctoral workforce in addressing complex challenges related to national security. This means that postdocs are one of the more unique workforces that work across the lab. Figure 5 shows the number of postdocs in each center at Sandia that has at least one postdoc. The mission work varies significantly depending on the center, reflecting the specific goals and objectives of each area. For instance, a postdoc in the Materials, Physical, and Chemical Sciences Center is more likely to be engaged in fundamental research, while a postdoc in the Global Security and Cooperation Center may focus on more applied research. It is critical to recognize that mentoring needs in a fundamental research environment may differ substantially from those in a more applied area. Postdocs in applied fields may require more mentoring in project management, whereas those in fundamental research may benefit from guidance on proposal writing for follow-on funding. Career goals are also likely to depend on this, so career goals are critical and should be taken into account by the mentor. If the postdoc's plan is to pursue fundamental research and their postdoc is in an applied area, then efforts should be made to enable the postdoc to work on projects elsewhere in the lab to shore up the fundamental research aspect of their curriculum vitae and resume.

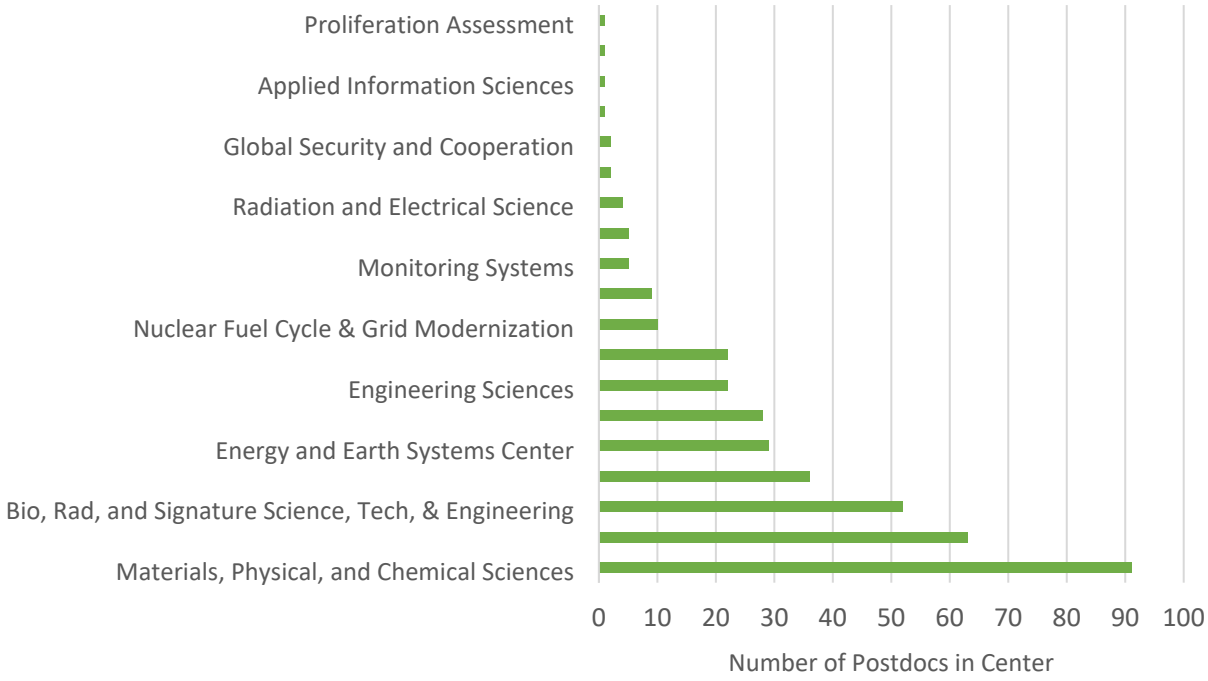


Figure 5. Postdocs per center *(data for FY24)*

As mentioned above, postdoctoral positions are limited term positions not to exceed six years with no further extension. The tenure distribution of postdocs at Sandia outlined in Figure 6 provides valuable insight into the workforce's experience levels. As of September 2024, 40.5% of postdocs have been in their roles for less than one year, suggesting a continual influx of new talent. Furthermore, 34.4% have been in their positions for one to two years, and 17.7% for two to three years. A small proportion, 4.4%, have been with the lab for three to four years, while those with over four years of experience make up the remaining 3%. This mix of experience levels contributes to a dynamic postdoctoral environment, where fresh ideas are complemented by the insights of more experienced researchers. As postdocs remain at Sandia for longer periods, they develop a deeper understanding of the laboratory's research landscape, institutional culture, and operational processes. However, extended time away from academia, industry, or governmental roles can begin posing challenges when applying skills outside the national lab complex. As such, postdoc mentors are challenged to consider the varying levels of experience and familiarity that their mentees bring to their roles, as those who have been at Sandia longer may require different types of guidance compared to newer postdocs. Additionally, mentors need to be aware of the evolving needs of their mentees over time, as longer-tenured postdocs may seek more advanced mentorship in areas such as funding acquisition, project leadership and career development, while newer postdocs may need foundational support in navigating the laboratory environment.

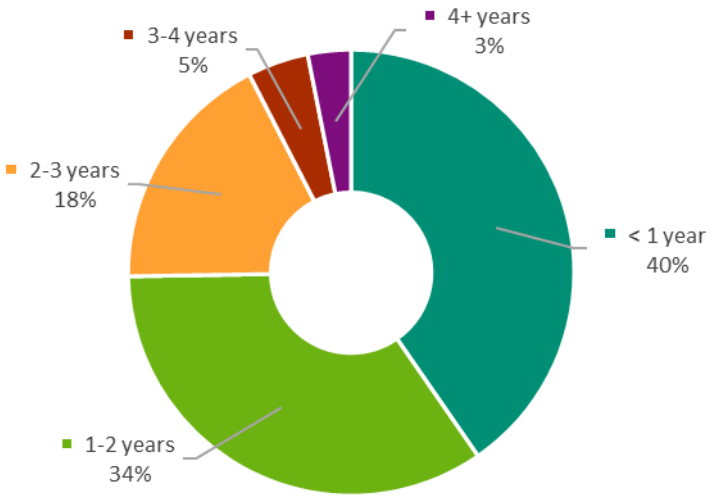


Figure 6. Current postdocs time in job *(data for FY24)*

The diversity of the postdoc workforce at Sandia is mirrored in the demographics of their mentors. Typically, postdoc mentors are situated within the same or a closely related group as their mentees, ensuring a technical alignment that facilitates effective guidance and collaboration. Postdocs are usually mentored by Sandia staff members, some of whom may have previously held postdoctoral positions themselves. While it is challenging to identify every staff member who has served as a mentor to a postdoc, the Postdoctoral Program Office (PDO) has begun to collect relevant data. Since September 2023, the PDO has requested that postdocs identify their mentors, with outreach efforts increasing in frequency throughout 2024 and into 2025. As of July 2025, a total of 436 postdocs have reported their mentors through this initiative. Among the identified mentors, there are 548 staff members and postdocs, with 151 postdocs noting two mentors each. Notably, 96 of these mentors are former Sandia postdocs, highlighting the continuity of experience within the mentoring framework. Additionally, 21 mentors have been recognized for mentoring multiple postdocs, indicating their active role in fostering the development of early-career researchers at Sandia.

Overall, the unique backgrounds and experiences of mentors and mentees necessitate a flexible approach to mentorship that accommodates different disciplines and lab divisions. Understanding these dynamics is crucial for establishing effective mentoring relationships that align with the specific needs of each postdoc. In the following section, we will explore the roles and responsibilities of mentors and mentees at Sandia, emphasizing the importance of clearly defined expectations to foster productive and supportive mentorship experiences.

4. ANALYSIS 1: ROLES AND RESPONSIBILITIES OF POSTDOCTORAL MENTORS AND MENTEES AT SANDIA

Defining roles and responsibilities in a postdoctoral mentorship is crucial for effective mentoring and is frequently the first-line effort in defining what effective mentorship looks like at specific institutions. Clearly defining roles and responsibilities provides clarity and sets expectations to ensure that both the mentor and the postdoc understand their respective roles and are aligned in their goals. This clarity reduces ambiguity and fosters accountability, as each party can be held responsible for their contributions, promoting a sense of ownership and commitment to the mentorship process. Additionally, well-defined roles facilitate effective communication, streamlining discussions and ensuring that important topics are addressed appropriately. This allows the postdoc to focus on developing specific skills relevant to their career goals, while mentors can tailor their guidance accordingly. Understanding roles aids in the efficient allocation of resources, such as time and funding, maximizing productivity for both parties. In the event of conflicts, having defined roles provides a framework for constructive resolution. A defined structure also helps identify opportunities for professional growth, as mentors can guide postdocs toward networking, publishing, and other career-enhancing activities based on their responsibilities. Clearly articulated roles enable the establishment of specific, measurable goals, leading to more focused research outcomes and clearer paths to achieving career aspirations.

Overall, defined roles and responsibilities create an environment that promotes effective collaboration, enhances learning, and supports the professional development of the postdoc, leading to more successful research outcomes. These roles and responsibilities should be defined within the specific mentoring relationship as these should be specific to the mentor-mentee pairing. In an effort to provide consistent guidance to postdoc mentor-mentee pairs, Sandia held a workshop in 2024 with the Material, Chemical, and Physics Research Center (Center 1800, the center employing the most postdocs over the last 10 years) to develop a deeper understanding of both mentor and mentee roles and responsibilities at Sandia. The workshop started with a seminar given by Dr. Melissa McDaniels from the Center for Improvement of Mentored Research from the University of Wisconsin-Madison, titled "Advancing the Science and Practice of Mentorship in National Laboratories", and after the seminar Level 1 Managers, staff members, and postdocs engaged in a working session to determine the broad roles and responsibilities in postdoctoral mentorship at Sandia. Attendees were split into groups based on job titles and brainstormed what the roles and responsibilities were for each job title with respect to working on research with postdocs or as a postdoc. For example, each group identified what they perceived that the responsibilities were of Level 1 Managers for postdocs. This was then compiled into a consensus-built summary of the who and what is involved in postdoctoral mentorship at Sandia.

4.1. A Postdoc's Role in their Own Success

Figure 7. Postdoctoral roles and responsibilities in their own success.

First off, a coherent understanding of the postdocs role in their own success is crucial to building efficient mentor-mentee relationships. During the workshop, five main responsibilities were identified for postdoctoral appointees. These responsibilities were summarized into five main groups: 1) taking initiative and demonstrating leadership, 2) performing high-quality scientific work, 3) maintaining effective communication, 4) contributing to their own professional development, and 5) expanding their professional network. By embracing these responsibilities, postdocs can not only enhance their own careers but also positively impact their teams and the broader organizational goals.

To elaborate on these responsibilities, postdocs are encouraged to take initiative by being self-starters who actively seek out opportunities for growth and learning, while also bringing enthusiasm and fresh perspectives to their projects. They must perform good scientific work by executing assigned tasks rigorously, following the scientific method, and being safety-minded. Effective communication is vital; postdocs should engage openly with their mentors and colleagues, provide constructive feedback, and articulate their career goals. Additionally, contributing to their own professional development involves having a clear career vision, participating in mentorship opportunities, and continuously improving their technical skills through publications and presentations. Finally, expanding their network is crucial, as postdocs should leverage organizational opportunities, collaborate with peers, and understand how their work aligns with Sandia's mission. These five main categories are explored more in Figure 7.

4.2. Roles (Who?)

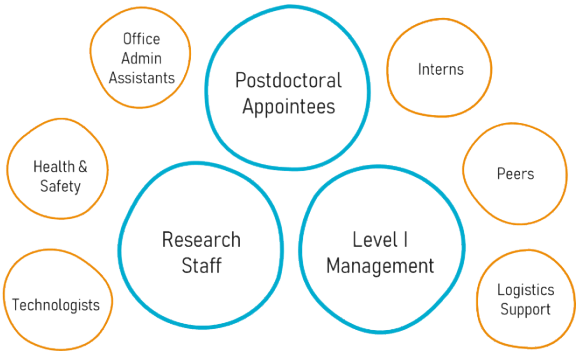


Figure 8. Key personnel that postdocs may work with directly and frequently in the postdoctoral experience at Sandia.

As mentioned, postdocs are key to their own success, which was emphasized by workshop attendees by their use of self-focused words: self-starter, self-motivated, self-reflective. However, an effective postdoctoral experience necessitates engaging with experienced researchers to gain valuable guidance, feedback, and access to resources that enhance the quality of their work. From an organization perspective, being part of a research team fosters accountability, encourages skill development, and helps postdocs integrate into the scientific community, ultimately preparing them for future roles as independent scientists- all items that were identified as key responsibilities. The three key players in postdoctoral mentorship were, unsurprisingly, identified as postdoctoral appointees, research staff, and level one management with additional positions at Sandia playing smaller, more discrete roles in the postdoctoral experience (Figure 8).

4.3. Responsibilities (What?)

Staff members were identified to have more hands-on responsibilities in mentorship compared with management, serving as primary mentors while management more frequently serves as a secondary mentor for both postdocs and staff. Staff members are tasked as the primary technical mentor, providing specific feedback on technical and soft skill development. They foster opportunities for technical development and network development based on skill development and use their own networks to advance and support postdoc pathfinding and exploration of career perspectives.

The most common management specific responsibility is to connect the postdoc to the Sandia ecosystem and to oversee the mentor-mentee relationship between the postdoc and staff member, or more specifically to ensure that individual postdocs get appropriate technical mentorship, that the mentor-mentee relationship adheres to Sandia standards of behavior, and to provide supplemental corporate mentorship. Managers are in a unique position to balance career development opportunities and growth opportunities concurrently for both the postdoc and the staff member.

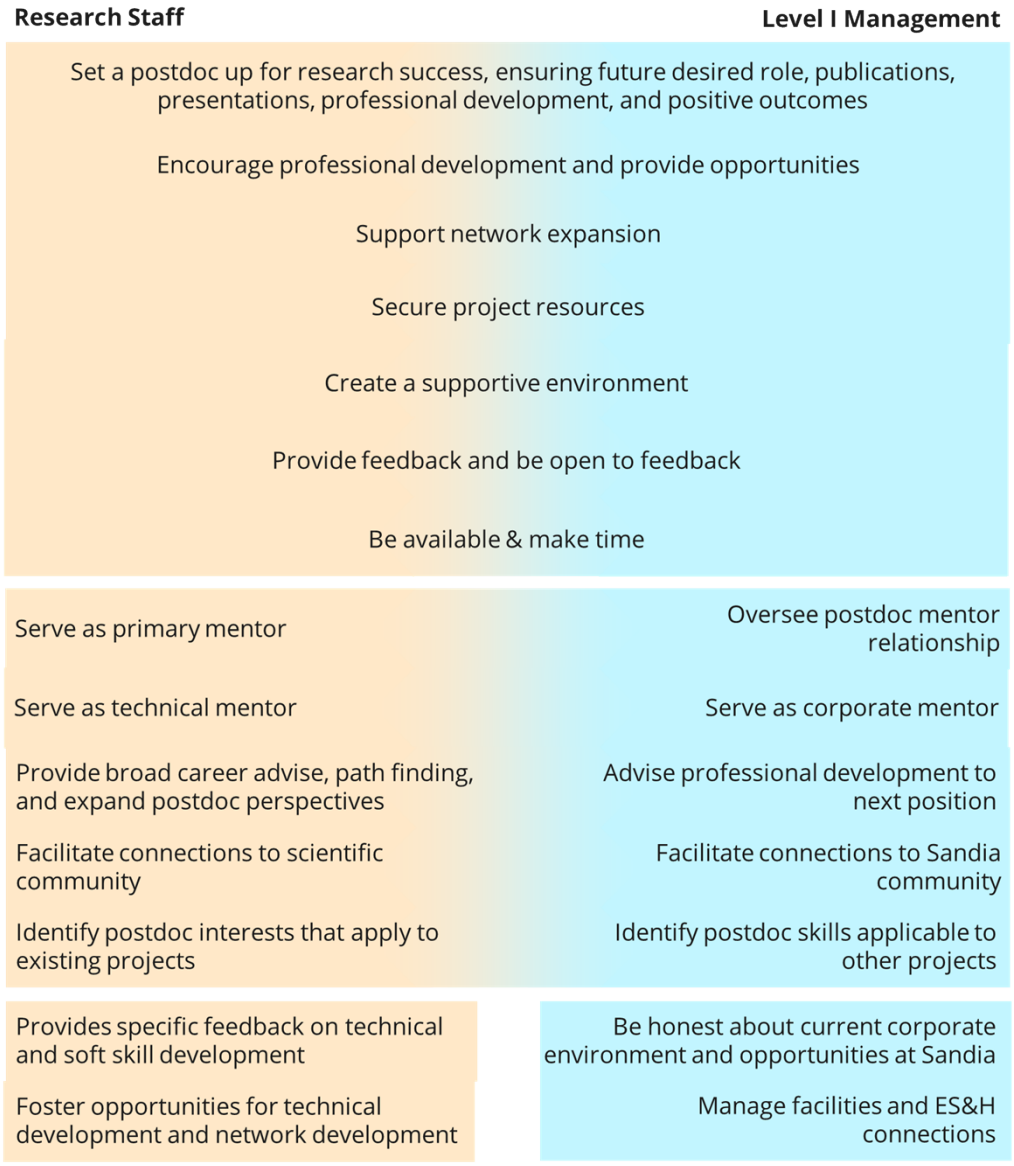


Figure 9. Defined roles and responsibilities in postdoctoral mentorship developed by postdocs and their mentors.

Frequently, research staff and level one managers have similar responsibilities, but which differ in their execution. While a staff member may act as a technical mentor, management acts as a corporate mentor. Staff members provide broad career advise based on their experiences while management advises targeted professional development to a specific position. Staff mentors facilitate connections to the broader scientific community, which may include inside and outside of Sandia, while managers facilitate connections inside the Sandia community. Similarly, staff mentors identify postdoc interests that apply to existing projects and portfolios, while management analyzes how postdoc existing and future skills are applicable to other projects and portfolios, keeping an eye on broader trends in the group, center, division, and Sandia-wide.

Regardless of job title, both research staff and level one managers are tasked with setting up postdocs for research success by maintaining understanding of the postdocs future desired role and by supporting opportunities for publications, presentations, professional development, and positive research outcomes. They encourage professional development, provide opportunities, and support network expansion. Both secure the required resources for projects,

particularly given the short term of a postdoc with the challenges of working at a national lab. Research and management mentors should provide timely feedback and be open to feedback, and finally create a supportive environment, be available, and make time for the postdoc.

As mentioned earlier, identified to have a smaller, but still key role in the postdoctoral experience are interns, peers, finance logistics support, office administrative assistants, environmental health and safety professionals, and technologists. The intern role is to work with postdocs through an iterative, scientific method. Peers should be open to new ideas and concerns, as well as generally helpful with networking and situating postdocs in the department, building, and lab. Finance support staff are critical to provide input on training and budget, specifically for internal processes or in the case where external funding is managed internally. Office administrative assistants are key players for day-to-day tasks including onboarding, managing training requirements, scheduling, and a first line of assistance as point of contact for all things Sandia. Environmental health and safety professionals give perspective on safety and help identify resources needed for safe work. Finally, technologists interface directly with postdoctoral research by teaching postdocs new technical skills, providing direct R&D support or fabrication support. Additionally, they can be involved directly in the technical execution of the project, they lend their specific experience working in specialized lab spaces, collaborate and team for success, and help with safety procedures.

As we delve deeper into the dynamics of postdoctoral mentorship, it is essential to recognize the unique considerations that shape these relationships within the context of Sandia National Laboratories. Now that we have a deeper understanding of the people involved and how they're involved, we can transition back to discussing what makes postdoctoral mentorship unique at Sandia.

5. ANALYSIS 2: UNIQUE CONSIDERATIONS FOR POSTDOCTORAL MENTORSHIP AT SANDIA NATIONAL LABS

The distinctive environment of a national lab, characterized by its mission-driven research, interdisciplinary collaboration, and security focus, presents specific challenges and opportunities for both mentors and mentees. Understanding these factors is crucial for optimizing the mentoring experience and ensuring that postdocs are effectively supported in their professional development. In this section, we will explore the unique aspects of postdoctoral mentorship at Sandia, highlighting the factors that influence mentoring practices. Here, we pull from various forms of data including: a 2018 CIMER workshop, postdoc exit surveys organized by the Postdoctoral Development Office, and annual postdoc surveys organized by the Sandia Postdoctoral Development Board.

5.1. What does it mean to be at a National Lab

First, we look at what we know of postdoctoral positions outside of Sandia as a contrast. At universities, research conducted under the guidance of faculty members is primarily driven by the grants that these faculty members secure. Postdocs and graduate students often assist in writing proposals, and faculty members enjoy a considerable degree of autonomy in determining the direction and scope of their research. The expectation for postdocs at universities is generally that they will not be hired as faculty members at that institution. Instead, they anticipate that the university and their research supervisors will provide them with the necessary resources and support to advance to the next stage of their careers. Additionally, research conducted in this setting is typically aimed at publication in academic journals. In the industrial sector, research is profit-driven, meaning that as long as there is funding available, research can be pursued. This research may often be proprietary, with a focus on developing products or technologies that generate revenue. In this context, there is an assumption that postdocs may be considered for permanent positions within the company upon completion of their postdoctoral tenure.

In contrast, research at national laboratories like Sandia is mission-driven, focusing on addressing specific national security challenges and broader societal needs. While fundamental research may still be a component, it is conducted with the understanding that it serves a larger goal beyond the individual principal investigator (PI). Postdocs at Sandia are expected to align their research with these mission objectives, contributing to the laboratory's overarching goals. While securing a job at a national lab is not guaranteed, many postdocs are interested in securing a position at Sandia. From a fiscal year 21 (October 2020 – September 2021) annual survey sent to postdocs by the Sandia Postdoctoral Development Association, we learned that the majority of surveyed postdocs stated they were interested in a national lab postdoc in order to pursue longer term employment opportunities at Sandia or other Department of Energy National Laboratories. When surveyed again in fiscal year 2022 (October 2021 – September 2022), 83% of postdoc responders were interested in a full-term staff position at Sandia. When deciding to pursue training at Sandia, an equal number of respondents stated that training, the opportunity to work with specific people on specific projects, the compensation scheme, and work-life balance were their top motivators. In general, these individuals would prefer a full-term position at their current site, usually referring to the California Sandia site or the New Mexico Sandia site, whereas only 34% said they would be interested in the position at another Sandia site. In contrast, 43% of responders said they would be interested in a full-term staff position in another field of study. 66% stated that they would be interested in a full-term staff position at another DOE national laboratory, regardless of location. The second most popular employment choice was industry, with 42% of respondents stating they were interested. Only 23% of respondents were interested in an academic position, but an additional 21% would consider academia if that was their only option.

This builds a compelling narrative that the majority of Sandia postdocs are interested in continuing to work within the national lab complex. At Sandia, U.S. citizen postdocs often have a favorable chance of being hired for permanent positions within the laboratory after their postdoctoral appointments. For non-U.S. citizen postdocs, the experience is frequently viewed as a valuable training opportunity, providing them with skills and knowledge that can enhance their future career prospects, whether in academia, industry, or other research institutions. Figure 10 shows the

number of PhDs hired into a postdoc position at Sandia ("Number of Postdocs Hired"), the number of postdocs hired into staff positions ("Number of Postdocs Hired as Staff"), and the number of postdocs leaving Sandia ("Postdocs leaving Sandia").

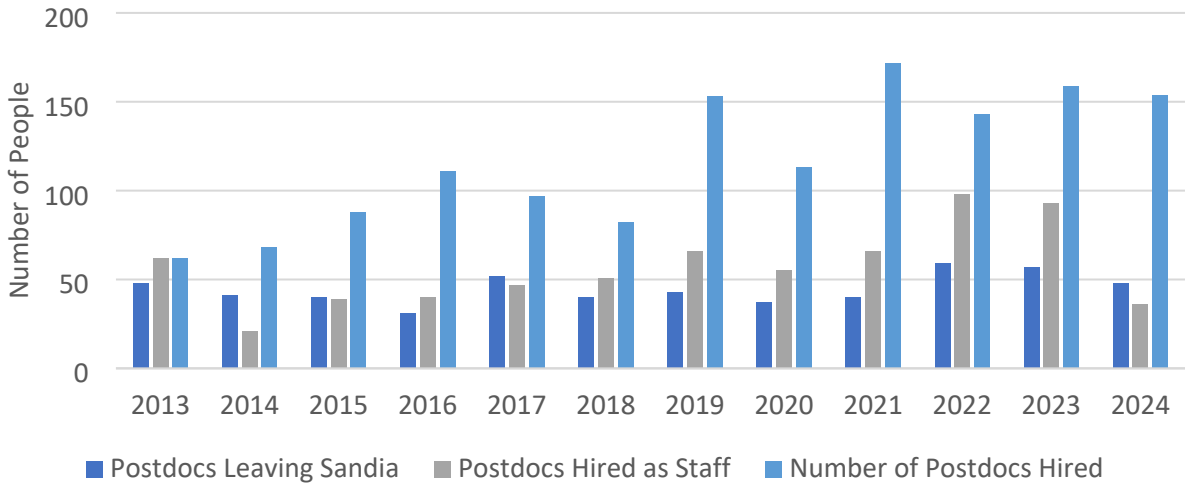


Figure 10. Hiring statistics for postdocs into, out of, and converted to staff at Sandia.

At the same time, national lab funding shifts naturally occur with administration change, making the funding environment and therefore the technical environment of a FFRDC like Sandia also fluid in how mission-work is executed. Sandia is a national security lab and threat environments are constantly changing so Sandia changes to meet the current national needs, which can complicate career trajectories of postdoctoral appointees. For example, the CHIPS and Science Act of 2022, officially known as the Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022, is a U.S. law aimed at boosting domestic semiconductor manufacturing and research and strengthening the nation's scientific and technological workforce that impacted Sandia's mission portfolio. Sandia was the first national lab to join the U.S. National Semiconductor Technology Center through partnership established via CHIPS, strengthening U.S. semiconductor manufacturing and R&D, helping national security production and fostering new technologies. Additional impacts on what constitutes the mission portfolio have been felt with the transition between the Biden Administration and the 2nd Trump Administration, with Sandia remaining flexible to meeting the nation's needs. This means that a postdoc may join the lab and find their area of research reprioritized, a situation in which a mentor that understands this natural shift in security needs can make all the difference. While funding shifts also occur in academia and industry, the nature with which they do so in the national lab complex is a point of confusion for postdoctoral researchers coming from academia. This is just one example of how postdoctoral mentoring needs differ at Sandia, and we will discuss more throughout this section, looking at data from 2018 till now to inform us.

5.2. Key Concerns in Mentorship

In 2018, a workshop was held in partnership with the Center for Improvement of Mentored Experiences in Research (CIMER), a nonprofit organization funded by the National Science Foundation and other federal agencies aimed at improving mentoring practices in research environments. The workshop sought to understand the specific considerations for postdoctoral mentorship at national labs, focusing on a central question posed to both postdocs and their mentors: "What concerns do you have about mentoring/being a mentee?"

Concerns about postdoc mentorship stemmed from both postdocs and mentors regarding communication issues (funding transparency and project roles), expectations and accountability (publishing, professional development, and mentoring accountability), guidance and support (mix of research and customer work and co-mentoring dynamics), challenges faced by mentor-less postdocs (ad-hoc support and technical work focus), performance feedback (vague expectations and lack of feedback mechanisms), understanding responsibilities (deliverables confusion and original research versus funded projects), the learning environment (limited intellectual community and importance of conferences), balancing independence and oversight (micromanagement versus trust), the temporary nature of postdoc positions (distraction from research), and mentor authority (challenges in managing postdocs without direct authority).

Postdoc-specific concerns included the need for funding transparency, as clear communication about funding timelines was essential for understanding project continuity. They emphasized the importance of professional development, particularly when projects did not offer opportunities for publication or intellectual property. This frequently was the difference between postdocs feeling perceived as cost-effective labor rather than members of a technical research team. Also a concern was the potential lack of mentoring accountability, with technical mentors potentially receiving credit for having a postdoc involved regardless of their effectiveness in guiding postdocs. Along the same line, some postdocs expressed that they experienced ad-hoc support due to the absence of formal mentorship, leading to inconsistent guidance and stalled career progression. Finally, postdoc participants pointed out that the security posture at the lab hindered their ability to learn from peers and faculty, especially for those transitioning to new fields. While postdocs are aware of the security posture before onboarding, a culture of operational security bleeds into non-sensitive areas and can make contacting those outside their own bubble difficult.

Mentor-specific concerns noted that staff members often lack the authority to influence postdoc hiring and termination decisions, complicating the mentorship relationship and accountability. They expressed concern that the pressure on postdocs to secure permanent positions can distract them from focusing on their research, complicating mentorship dynamics. Additionally, mentors identified the challenge of finding the right balance between providing guidance and allowing postdocs independence, particularly given the diverse backgrounds of the postdocs they work with. Finally, there was recognition that postdocs may not fully grasp their responsibilities regarding project deliverables, leading to misalignment with the expectations of principal investigators.

There were also shared concerns by postdocs and postdoc mentors. Participants expressed uncertainty about the roles of principal investigators (PIs) versus postdocs in experiments and lab work, emphasizing the need for clearer definitions of responsibilities. They also identified the importance of establishing clear expectations regarding publication and authorship to avoid misunderstandings. Finding the right balance between research responsibilities and customer work was recognized as crucial for postdoc development. Additionally, questions arose about the effectiveness of co-mentoring arrangements, with discussions on whether one mentor should take the lead

"Postdocs can be viewed as cheap labor, which manifests as a large focus on technical work and little focus on professional development."

"Universities can be places of 'open' intellectual community where postdocs can learn from other postdocs, faculty, etc. It's much, much harder here."

"Finding the right balance of involvement is crucial to ensure that the experiments and analysis are performed correctly without micromanaging the postdoc's time."

"As a staff member, I feel that I have control over the hiring process; however, once the postdoc is hired, they realize that the manager is the one with the authority to terminate positions."

- Concerns shared by postdocs and postdoc mentors during a 2018 workshop

to prevent confusion. Participants noted the ambiguity surrounding the ownership of work and the roles of various mentors, which made it difficult for postdocs to understand their performance. The lack of feedback mechanisms was also a concern, as postdocs do not participate in performance reviews, limiting their opportunities for constructive feedback. Furthermore, the expectation for postdocs to contribute uniquely while working on funded projects created confusion about their roles. Lastly, participants highlighted the importance of conferences as critical opportunities for postdocs to engage with broader scientific communities, while also noting that presentations often require multiple levels of review and may involve work that funders do not want presented.

We can combine these insights with responses pulled from annual postdoc surveys administered to the postdoctoral community by the Sandia Postdoctoral Development Association between 2017 and 2023. The following topics were brought up multiple times by postdocs in their free response answers: team composition and reliance on technologists leading to project delays; the balance between deliverable culture and research culture; employment opportunities and the financial implications of transitioning from postdoc positions; confusion regarding external grant applications and the desire for a grace period; limited mentoring and teaching opportunities due to security clearance; constraints on publishing, especially in open-access formats; challenges in presenting research due to complex approval processes; fiscal year constraints affecting conference participation; and difficulties in finding time to apply for professor positions.

5.3. Insights from Previous Postdocs

Next, we'll look at another source of data. Since 2021, postdocs can choose to fill out an optional exit survey form managed by the Postdoc Office upon separation from their postdoc position with the lab, either upon accepting a position to stay at SNL or upon finding work externally. In addition to those who have answered since 2021, we also sent the survey to all staff at Sandia who had transitioned from their Sandia postdoc position to a staff position since October 2017 and analyzed for insights into the mentoring experience these postdocs had. Due to the nature of the exit survey, and the fact that the Postdoc Office doesn't have a mechanism to know or understand who is leaving and when, the majority of exit survey respondents (76 of 96) are postdocs who transitioned to a staff position at Sandia and retained their Sandia emails, indicating the survey results are broadly indicative of how people who transitioned from postdoc to staff member at Sandia viewed mentorship during their postdoctoral appointment. Looking at years with more than 10 responses to the exit survey, mentors were consistently more likely to meet with postdocs regularly to help them achieve their research goals rather than their career goals.

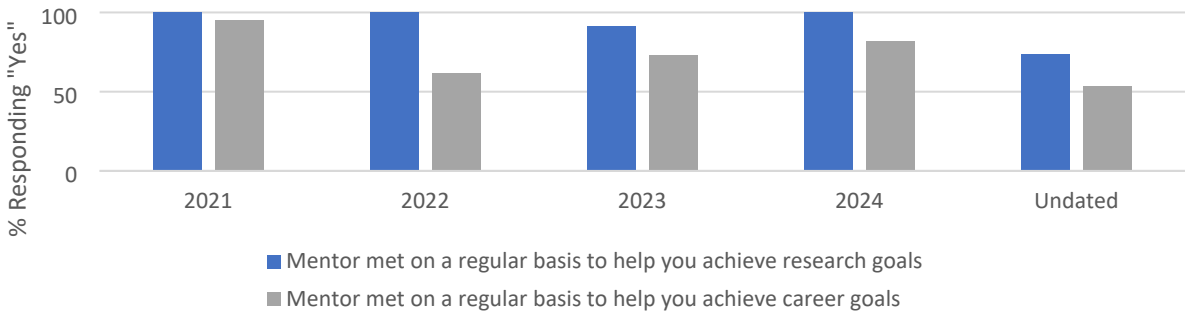


Figure 11. Optional exist survey responses on regular meetings to achieve research vs career goals.

Free response answers highlight the challenges associated with co-mentoring arrangements, emphasizing that splitting a postdoc between multiple mentors, while sometimes necessary when performing customer-focused work, can lead to diminished progress and attention on each project. This suggests that careful consideration is needed when implementing such arrangements to ensure effective support. Additionally, several postdocs expressed a desire for better support in transitioning to staff positions, noting that while their mentors were generally supportive, they often lacked the ability to assist with career transitions outside their training domain. This indicates a need for mentors to be more adaptable and knowledgeable about various career paths.

While many postdocs reported a positive overall experience, specific challenges emerged, particularly the impact of COVID-19 on travel and networking opportunities. Positive experiences were frequently attributed to supportive managers and mentors who facilitated connections and provided guidance. However, a recurring theme was the limited opportunities for publishing and presenting research, with some postdocs feeling that their roles did not align with publication expectations, negatively impacting their career development. The quality of mentorship varied significantly, with some respondents enjoying excellent relationships with their mentors, while others experienced strained relationships or a lack of engagement from their managers.

Moreover, lengthy processes for obtaining security clearance were cited as barriers to effective work and mentorship, limiting postdocs' ability to engage fully in their projects, especially given the limited timeline of a postdoctoral position. Some postdocs expressed dissatisfaction with the absence of a clear development plan and career goals, indicating a desire for more structured guidance, which is essential for developing skills necessary for success in staff roles. Comments regarding the work environment varied, with some describing a supportive atmosphere and others reporting toxic conditions and a lack of resources.

5.4. Unique Considerations for Postdoctoral Mentorship at Sandia

We have synthesized the information from all three sources above into the following special considerations for postdoctoral mentoring at Sandia.

5.4.1. Unique Collaborative Dynamics

The team composition at Sandia includes a diverse mix of interns, technologists, limited-term staff, management, and staff members at various levels (member, senior, principle, and distinguished increased in experience). Technologists play a critical role in project execution, particularly in specialized tasks such as fabrication and technical support, which postdocs may not be permitted to perform due to safety and security protocols. This reliance on technologists can lead to perceived delays in project timelines, as postdocs must wait for these essential tasks to be completed before they can advance their research. Additionally, the work environment at Sandia is characterized by enhanced oversight, where staff and managers ensure that all research activities remain mission-relevant, justifiable in terms of taxpayer funding, and most importantly are up to the highest levels of conformance for safety. This dynamic can create a sense of frustration among postdocs, who may feel their progress is hindered by factors outside their control. Additionally, the work environment at Sandia is characterized by enhanced oversight, ensuring that all research activities remain mission-relevant and compliant with safety standards. Unlike in academia, where researchers typically have the autonomy to drive their projects forward independently on the fastest time frame they are capable of working towards, postdocs may feel constrained by the need to align their research with the immediate goals of their teams and rely on others for aspects of projects. Such oversight can contribute to feelings of being monitored excessively, which can impact postdocs' confidence in their autonomy and ability to develop as independent scientists.

5.4.2. Tension Between Research and Deliverable Cultures

The work culture at national laboratories emphasizes a balance between project deliverables and the flexibility to redirect research questions as needed. Sandia frequently exists at the intersection of deliverable culture and research culture. In a deliverable culture, the primary focus is on achieving specific, predefined outcomes within set timelines, driven by the need to meet project milestones, secure funding, and demonstrate progress to stakeholders. In contrast, a research culture emphasizes the pursuit of knowledge, innovation, and intellectual exploration. Researchers in this environment are encouraged to ask questions, explore new ideas, and engage in long-term projects that may not have immediate outcomes. Postdocs may be motivated by the desire to explore innovative research questions and contribute to scientific knowledge. However, staff members, who may be more entrenched in the deliverable culture, might prioritize meeting project deadlines and achieving specific outcomes due to working for a specific

customer. This misalignment can lead to stress and dissatisfaction between postdocs and staff as postdocs navigate competing expectations from their mentors and the organization, potentially resulting in burnout and a lack of engagement with their research. This can lead to conflicts over the direction of research and the allocation of time and resources.

5.4.3. Dynamic Funding Environment

Sandia National Laboratories operates within a unique funding and operational environment that distinguishes it from academic institutions. The funding landscape at national labs is subject to shifts that can occur with changes in administration, which directly impacts how mission-driven work is executed. As a national security laboratory, Sandia must remain agile in response to evolving threats and national needs, leading to a fluid technical environment. This need for agility can lead to a reactive rather than proactive approach to research, which may stifle innovation for postdocs just learning to navigate this unique environment. Postdoctoral researchers may find that their areas of focus are reprioritized based on the current national agenda, making it crucial for mentors to understand and navigate these dynamics effectively. Additionally, postdocs, due to the expected short-term tenure of their position, may be passed over from the consideration for leading research projects as principal investigators, especially when those are for long periods (2-3 years) due to the concern that a postdoc may not have the tenure to complete the project. This is particularly pertinent in customer-specific work. If the postdoc wants to stay at Sandia, they may need to have funding lined up to make that possible. If they want to go into academia, they need to demonstrate having written successful grant proposals. Another factor is the lack of overhead applied to postdoc billing hours, which reduces their cost significantly when compared to staff members. This makes postdocs cost-effective and therefore agile on portfolios but also creates significant tensions when discussing conversion to a staff member as their hourly cost on projects skyrockets. This is a challenge as there may be pressures to prolong their postdoc tenure rather than elevating them to staff, particularly if their body of work includes slimmer budgeted projects.

5.4.4. Professional Development Barriers

Unlike academia, where postdocs often have ample opportunities and are even expected to engage in teaching and mentoring roles, postdocs at Sandia encounter more limited avenues for these activities. Furthermore, the primary focus at national laboratories is on research and project deliverables, which can restrict the time and resources available for mentoring, teaching, and professional development engagements. As a result, the emphasis on project deliverables can restrict the time and resources available for postdocs to engage in broader professional development activities that foster their growth as educators and researchers. While summer interns may provide some opportunities for mentorship, the overall scope is narrower compared to the more structured mentoring environments found in academic settings. Consequently, this limitation can hinder postdocs' ability to develop essential teaching and mentoring skills and gain experience that is often critical for securing future academic positions, potentially leading to a lack of preparedness for the job market. Additionally, the presence of security clearance requirements can limit postdocs' ability to engage with students or junior researchers who do not possess the necessary clearances and/or access seminars in areas with stricter controls. In particular, postdocs may not be able to attend seminars and expand their network because they lack the proper clearance to access the area where the seminar is being delivered. These requirements may limit postdocs' ability to collaborate with peers, engage in mentoring relationships, or participate in external networking opportunities. Ultimately, postdocs may find it challenging to build the professional networks and skills necessary for career advancement. They are often in a transitional phase of their careers, seeking to build their skills and establish their professional identities. However, the emphasis on deliverables may limit their opportunities for mentorship and professional development, as staff members may prioritize immediate project needs over long-term career growth for postdocs. Moreover, postdocs may struggle to find the flexibility needed to apply for external positions. The demands of their current roles can limit the time available for job applications and interviews, adding another layer of complexity to their career progression.

5.4.5. Challenges with Publishing and Presenting

Working at a high-security enterprise means postdoctoral researchers face distinct challenges regarding publishing and presenting their work. One of the primary constraints is the limited availability of publishing opportunities, particularly in open-access formats. In contrast, while open-access publishing is increasingly valued in academia for its potential to enhance visibility and accessibility of research, postdocs at national laboratories may encounter barriers that restrict their ability to publish in these formats. The national mission-focus environment, along with requiring extra layers of funder approvals and increased scrutiny on language used and how it aligns with the funders' current funding environment, may lead to eventual absence from certain conferences. Moreover, security concerns inherent to the national lab environment complicate the presentation of research findings. Postdocs often must navigate a complex approval process involving multiple stakeholders, including funders and institutional review boards. Consequently, challenges associated with obtaining timely approvals for presentations can lead to missed opportunities for sharing research findings at conferences. These hurdles can lead to feelings of isolation among postdocs, as they may struggle to share their work and connect with the broader scientific community, ultimately affecting their professional reputation and career advancement. Additionally, these layers of oversight can lead to delays in obtaining necessary approvals, which may arrive too late for timely submissions to conferences or other presentation opportunities. Furthermore, the security concerns and funding constraints on what budget can be allocated to what can lead to restrictions on attendance at international conferences, as well as networking opportunities with researchers from countries on the Department of Energy Sensitive Country List. This situation adds constraints to the networking opportunities for postdocs, as well as their chances for international name recognition, which is increasingly emphasized in today's global research dynamics. Finally, working within the constraints of fiscal years can also impact postdocs, particularly regarding the timing of conferences and workshops. As a result, the alignment of project timelines with these events can be challenging, making it difficult for postdocs to participate fully in professional development opportunities.

These specific challenges represent the compromises that postdocs at Sandia must navigate in order to engage with the critical national security mission portfolio. While these unique considerations can complicate their professional development, they also underscore the importance of having knowledgeable mentors and proactive mentees. Together, they can effectively navigate these complexities, ensuring that postdocs can contribute meaningfully to national security efforts while advancing their own careers. In the next section, we'll hear directly from postdocs who have nominated their mentors as exemplary examples of mentoring at Sandia.

6. ANALYSIS 3: EXISTING EVIDENCE FOR PRINCIPLES OF EFFECTIVE POSTDOC MENTORSHIP AT SANDIA

6.1. Distinguished Mentoring Award Program

As already discussed, we've covered the who and what for postdoctoral mentorship at Sandia as well special considerations for postdoctoral mentorship at Sandia. Finally, we'd like to discuss what we know about exemplary postdoctoral mentorship at Sandia. Since 2013, the Sandia Postdoctoral Development Board has facilitated the Distinguished Mentorship Award. This award was developed to acknowledge the value Sandia National Laboratories places on postdoctoral mentorship and is meant to highlight examples of outstanding mentorship by Sandia staff and line management and promote improved mentorship across the labs. Sandia postdocs and recent postdoc-to-staff converts are eligible to nominate technical advisors and managers, and multiple postdocs may write a joint nomination for a deserving nominee. Additionally, postdocs may nominate both a technical advisor and manager but must write separate letters of nomination. Postdocs are asked to clearly and concisely in less than 350 words, and using specific examples, describe how their mentor models Sandia's priorities that Sandia postdocs have the best Sandia experience possible and that Sandia postdocs are prepared for their next career. All technical advisors and managers nominated receive a nomination certificate and are recognized via email including all management levels up to the current lab director. Winners also receive a certificate and recognition at the annual Postdoctoral Technical Showcase. Here, we use text mining, sentiment analysis, and word correlations with text from the last four years the award was facilitated (with the exception of the 2025 season which occurred during paper revisions) in order to offer insight into the characteristics of mentorship that postdocs self-identify as exemplary.

6.2. Award Demographics

A total of 86 nominations were received over the latest four years the award was held (2019, 2022, 2023, and 2024) representing a total of 78 unique mentors nominated by 83 unique postdocs with eight winners and runners-up. While most postdocs (72) nominated one mentor, 11 postdocs nominated more than one mentor sometimes in the same year and sometimes in different years. We do know that at least in 2024, of the 364 unique postdocs on file, 22% (80) did not disclose a mentor, 50% (183) have one mentor, and 28% (101) have two mentors.

For the award, most mentors were also only nominated once (72), but there were six mentors that were nominated two or three times over the four years with one winning upon being nominated the second time. While many nominations are written by a single postdoc, postdocs can submit joint applications if multiple mentees want to nominate the same mentor in the same year. There have been only seven of these, five submitted by a group of two, and two submitted by a group of three. From that same 2024 polling, we know that of the 263 unique mentors that were disclosed by their mentees, 66% (173) mentor one postdoc, 23% (61) mentor two postdocs, 8.8% (23) mentor three postdocs, 1.5% (4) mentor four postdocs, and <1% (1) mentor five postdocs. In general, the average length of a postdoc at Sandia is 2-3 years, so it is likely that most mentors have engaged with just one to two postdocs since 2019.

Most postdocs with exemplary mentors found their mentors either before joining Sandia or within the same month that they were onboarded. Out of 86 total nominations, 76 nominations were for mentorship relationships that started at onboarding. The other ten nominations found their mentors three months, a year, or a couple years after onboarding.

To get an idea of if exemplary mentorship identified through the award was distributed across the postdoc population at Sandia, we compared the number of nominations by center with the number of postdocs across the subset of years we had nominations for. The majority of nominations have come from Divisions 1000 and 8000, which is in line with the largest postdoc populations (Figure 12A). While Division 6000 has a low number of postdocs, it has the highest

ratio of nominations to postdocs. This could be skewed due to the low number of postdocs and the recent nomination of a handful of mentors by groups of postdocs. However, it is worth considering that some centers with low numbers of postdocs have not received nominations for exemplary mentors over the last four years. When looking at centers with more than 10 postdocs over the four years, Division 1000 centers stand out.

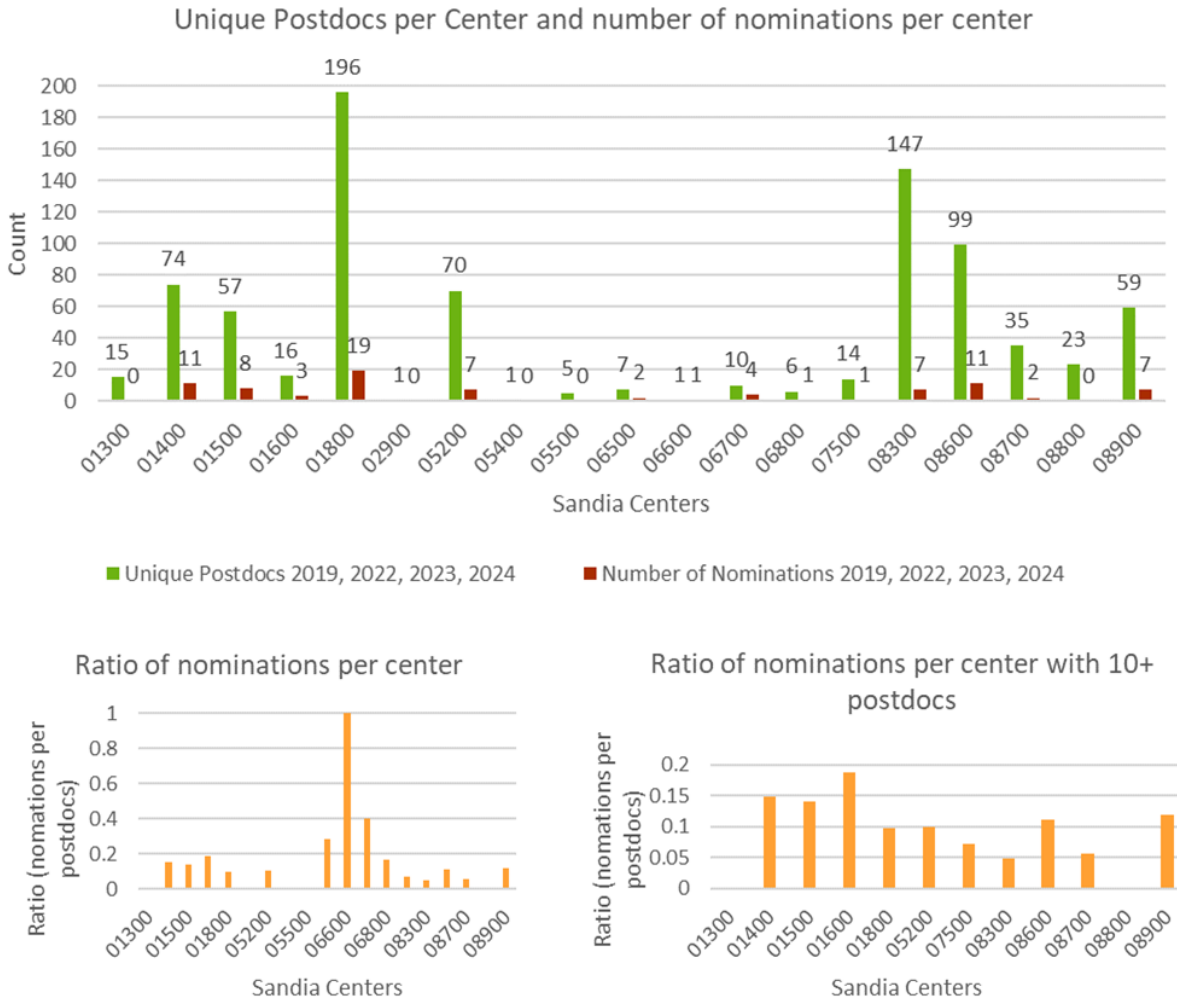


Figure 12. Representation of nominations across postdoc population.

6.3. Characteristics of Good Mentorship

Since few official documents exist outlining what good mentorship looks like at Sandia, we have taken nominations for the award as an opportunity to understand what postdocs value in their mentors and that their nominations represent the values, skills, and actions that postdoctoral appointees at Sandia value in their mentorship relationships. First, we focus on single words, also called unigrams. When looking at the most common words (Figure 13), after sorting out stop words and similar words that provide no semantic meaning, we found that "research", "career", "time", "project", "technical", "experience", and "projects", "helped", "staff", "field", "support", and "LDRD" all stood out as the most common words (>50 instances). This aligns with results from the roles and responsibilities section, where the primary role of a staff mentor at Sandia is to provide technical guidance and input. Also occurring at more than 20 instances were words like "writing", "conferences", "proposal", "feel", "growth", "teams", "funding",

"guidance", "opportunities", and "future" among many others. Other common words included "personal", "encouraged", "relevant", "learning", "role", "feedback", "exceptional", and "ensure".

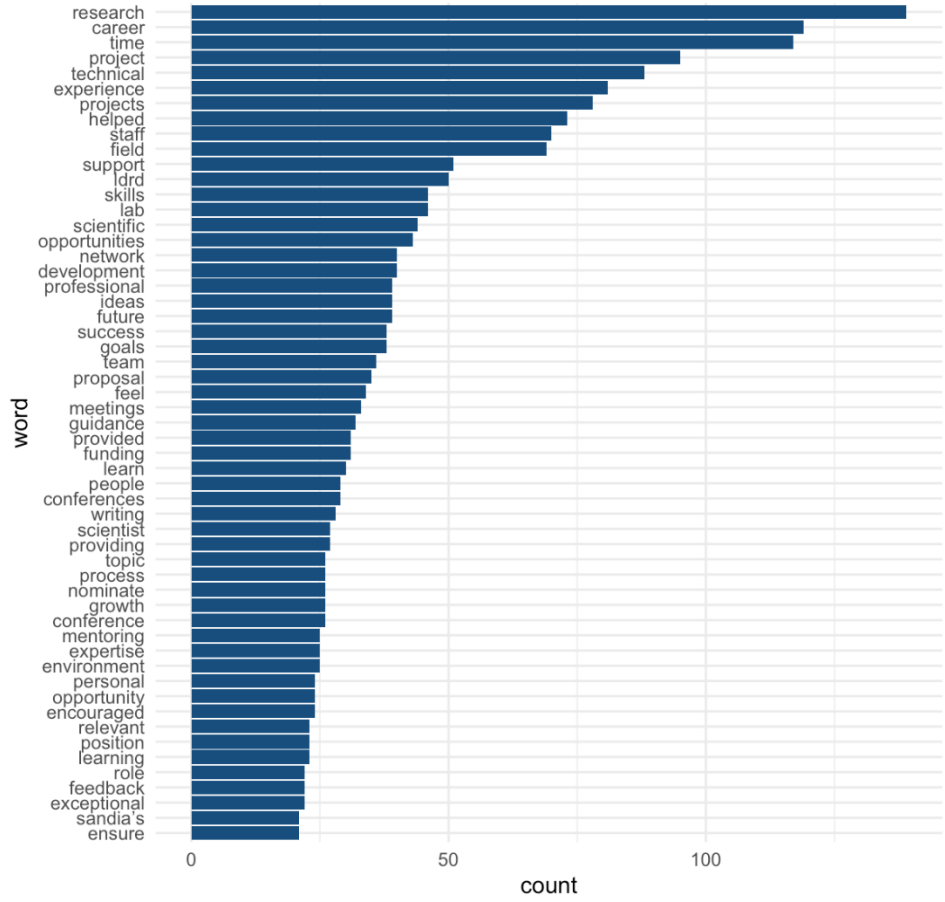


Figure 13. Most frequently used words in all nominations (at least 20 instances).

By analyzing the most frequently used words, we can gain valuable insights into the qualities that define an exceptional mentor, as identified by the nominators. These qualities can be categorized into three main areas: a) Research Advancement (e.g., research, project(s), LDRD, proposal, etc.), b) Career Growth (e.g., career, development, opportunities, position, network, etc.), and c) Support, Collaboration, and Communication (e.g., support, meetings, guidance, environment, etc.). This categorization clearly reflects the specific needs of early-stage researchers in postdoctoral positions within today's global professional landscape.

Initially, a mentor is essential not only for guiding the mentee through their scientific assignments and helping them develop the necessary skills but also for facilitating their transition to the responsibilities of an independent researcher. Additionally, mentors are expected to broaden the professional horizons of postdocs and illuminate pathways to career opportunities that may extend beyond the national lab environment or their current scientific field. Finally, the interpersonal skills of the mentor are highly valued by the nominators, particularly regarding the support and communication required to tailor the mentoring approach to each individual's personality.

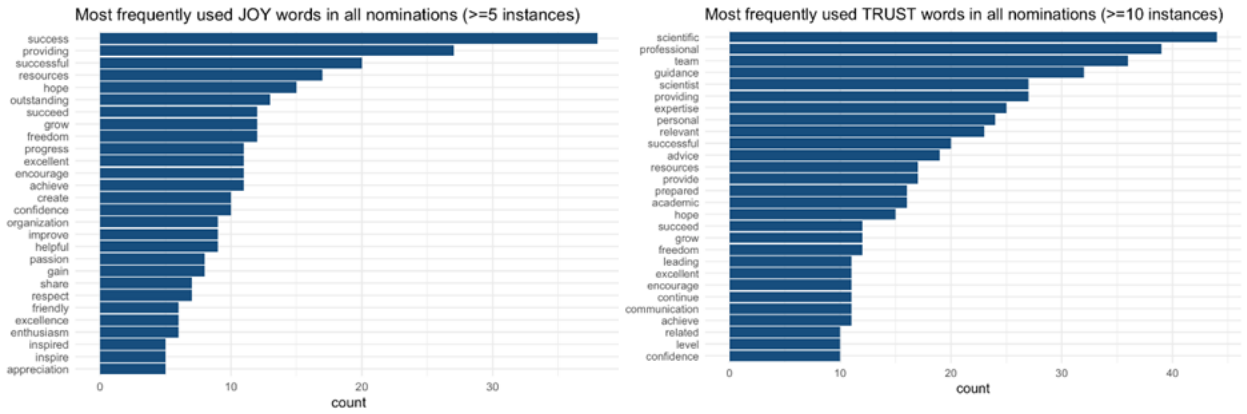


Figure 14. Most frequently used JOY and TRUST words in all nominations as defined by the National Research Council Canada (NRC) lexicon with at least 5 instances.

We also did a sentiment analysis of the nominations (Figure 15), which helps us understand the emotional context of the nominations. When human readers and writers read and write text, we use our understanding of the emotional intent of words to infer whether a section of text is positive or negative. For this section, we focus on more simple positive emotions like "joy" and "trust" from the National Research Council Canada (NRC) lexicon, a list of English words and their associations with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy, and disgust) and two sentiments (negative and positive). We did not find any consistent results when analyzing negative sentiment. Overall, trust words were more common compared with joy words with "scientific", "professional", "learn", and "guidance" dominating. Other trust words included "providing", "expertise", "personal", "relevant", "successful", "advice", "resources", "prepared", "hope", "encourage", "communication", and "confidence". Common joy words included "success/successful", "providing", "resources", "hope", "outstanding", "grow", "freedom", "progress", "excellent", "encourage", "achieve", "improve", "passion", "enthusiasm", "inspire", and "appreciation".

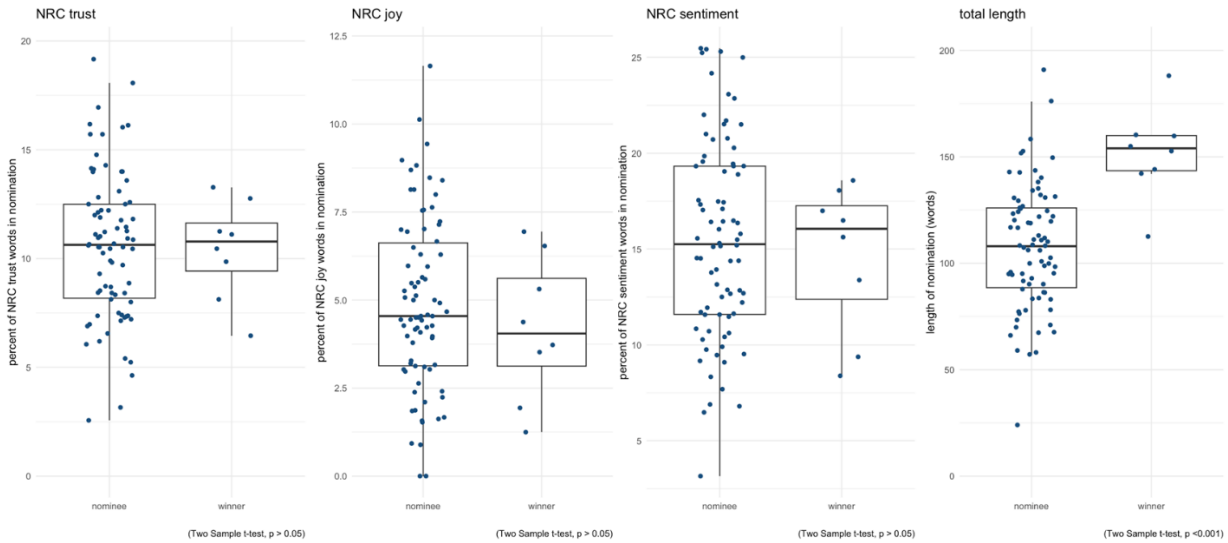


Figure 15. Comparative analysis between nominations and winning nominations.

We then tested to see if word usage for emotion or sentiment set the winners apart from the other nominations, but the only category where the compiled text of the winners was significantly different than that of just nominees was in

the length of the nomination, which could indicate that the longer the nomination the more likely it was to be chosen as a winner. Unfortunately, we currently do not have the power needed to differentiate other variables that could impact the likelihood of a nomination to be chosen by our judges, in this case previous nominees, as winners and would recommend support in future years to deepen this analysis.

In addition to unigrams, you can analyze bigrams (2-word phrases) or more generally called n-grams as you can simply increase n in order to look at word associations, relationships between words, and to get a broader understanding of the text. We've extended this n-gram into a network of words with at least one occurrence (Figure 16).

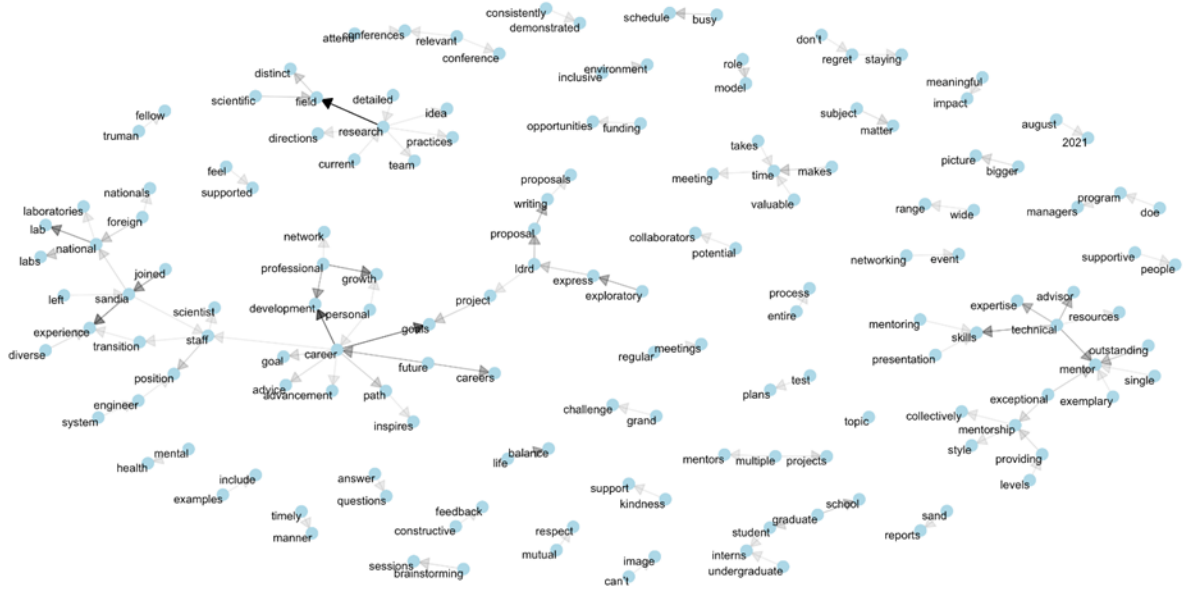


Figure 16. Bi-gram (two-word linkages) analysis of all nominations.

By looking at broader word associations, we see topics come out like: mental health, diverse experiences, feeling supported, work-life balance, mutual respect, SAND reports, plans and testing, DOE programming, role models, meaningful impact, inclusive environment, potential collaborators, opportunity for funding, entire process, wide range, and networking event. More complicated word networks include: inspiring growth, advancement, development, growth, networks, and goals; proposal writing and LDRD and LDRD Express opportunities; detailed research practices and team practices; juggling multiple projects and mentors; and technical expertise through presentations, collective mentorship, and providing resources.

From the word association figure there are three main word-groupings that are emerging, one around the word "career", one around "research" and another one around "mentor." This not only showcases the significance of those concepts to the nominators when it comes to justifying good mentorship in accordance to their needs, but also provides useful information to us on how those words are being defined by association to their neighboring concepts.

The biggest word network is developed around the word "career", connecting smaller networks around the words "sandia" and "ldrd". The most immediate word connections to "career" are words referring to upcoming professional opportunities like "advancement", "growth", "development", "goal", "path" and "future", while to more distant associations are referring to the current professional status of the nominators or the intra-institutional advancement, such as "sandia", "staff", "lab", "ldrd", "proposal" and "project". It is evident that career, being in the center of the

justification of good mentorship, is being explained as a chronological continuum with emphasis to the future steps but also defined by the current professional duties. For the nominators, thus, a good mentor is the one who helps them advance their career after their postdoctoral tenue, while at the same time facilitates taking advantage of the opportunities currently given by Sandia.

The second biggest network is the one around the word "mentor", which is being mostly associated with positive epithets like "outstanding", "exceptional" and "exemplary" and with words like "technical", "skills", "expertise" and "advisor". The later associations reveal the fact that in many cases the postdoc mentor is also their technical advisor and the duties coming from each role are often overlapping. Due to this overlap, technical support and advice are highly expected and positively evaluated for the Sandia mentors.

The last big word grouping is developed around "research", which is the "umbrella"-term defying horizontally the professional occupation of the postdocs in Sandia. The word "research" is linked with "field", "scientific", "directions", "detailed", "practices", "idea" and "team". Good mentorship is therefore linked with inspirational direction when it comes to research plans. Also, the fact that "team" is mentioned in association with "research" reveals the collaborative research environments that certain fields of the lab are encouraging and its importance in justifying an outstanding mentor.

Figure 17. Bi-gram (two-word linkages) analysis of winning nominations.

Nominations that resulted in winning (Figure 17) highlighted similar trends, while highlighting work-life balance, internal funding opportunities, proposal writing, role models, advice, foreign nationals, and graduate school.

In summary, the insights gathered from the Distinguished Mentorship Award nominations underscore the critical role that effective mentorship plays in shaping the postdoctoral experience at Sandia National Laboratories. The emphasis on career advancement, technical expertise, and collaborative research highlights the multifaceted nature of mentorship that postdocs value. As they navigate the unique challenges of working within a national security context, the support and guidance of mentors become essential for fostering professional growth and facilitating successful transitions to permanent positions. By recognizing and promoting exemplary mentorship practices, Sandia can enhance the overall experience for its postdoctoral researchers, ensuring they are well-prepared for their future careers while contributing meaningfully to the laboratory's mission.

REFERENCES

[1] SAND2024-16233M, **Sandia National Laboratories Strategic Plan** FY24-FY27: Updated for FY25

APPENDIX A. POSTDOC SELF-ASSESSMENT (PSA) WORKSHEET

Postdoc Self-Assessment (PSA) Worksheet

Name: _____
Technical Mentor: _____
Sandia Start Date: _____
Org: _____
Manager: _____
Employee ID: _____
Tentative date for next PSA meeting (six months from now): _____
Do you have a mentor who is neither your manager nor your technical mentor? Y/N _____

Part 1. Progress Review: Research and professional activity in the past 6 months (with dates of completion).

- If this is the initial PSA meeting, please list project goals instead.
- If this is a follow-up PSA meeting, please send your manager copies of previous PSA worksheets

Brief overview of your research project(s) and major accomplishments in the past year (one half page should be sufficient). For each project list the PI, PM, funding source, and approximate percent of your time. Explain how your contribution fits into the overall project goal(s).

Part 1. Progress Review, continued
Publications (submitted or published):
National or other professional meetings attended (indicate meeting title, oral or poster presentation):
Sandia presentations (title, host/org). Include PReSS seminars and the annual SPDA technical showcase (poster session):
New areas of research or technical expertise acquired in the past year:
Technical advances and/or patents filed:
Honors/Awards (eg: ERA nominations and awards, professional society presentation awards):
Membership and service to professional organizations (indicate if you held an office):
Other professional activities not identified above (mentoring students, scientific volunteerism):

Part 2. Research and other training plans for the next twelve months (with target dates):
Research project goals (brief paragraph):
Anticipated publications (indicate projected titles):
Anticipated meeting or workshop attendance:
Other professional training (eg: technical Sandia training, new skills to learn, workshops):

Part 3. Career goals:
Current career goal(s):
Where and how are you seeking your post-postdoc job? (can be N/A)
What further research activity or other training is needed before it is appropriate to start a job search?
When do you anticipate beginning a job search? (eg: Applications for academic positions are typically due in the fall, with an invitation to interview in the winter.)
How can Sandia support you in your job search? (eg: contacts at particular universities or companies; information on careers of previous postdocs in your org/division, opportunity to attend a particular conference, introductions to other organizations at Sandia...)

Part 4. Do you have any suggestions for improvement or concerns you would like to address? If you are more comfortable providing feedback in person, please contact the Postdoc Office.

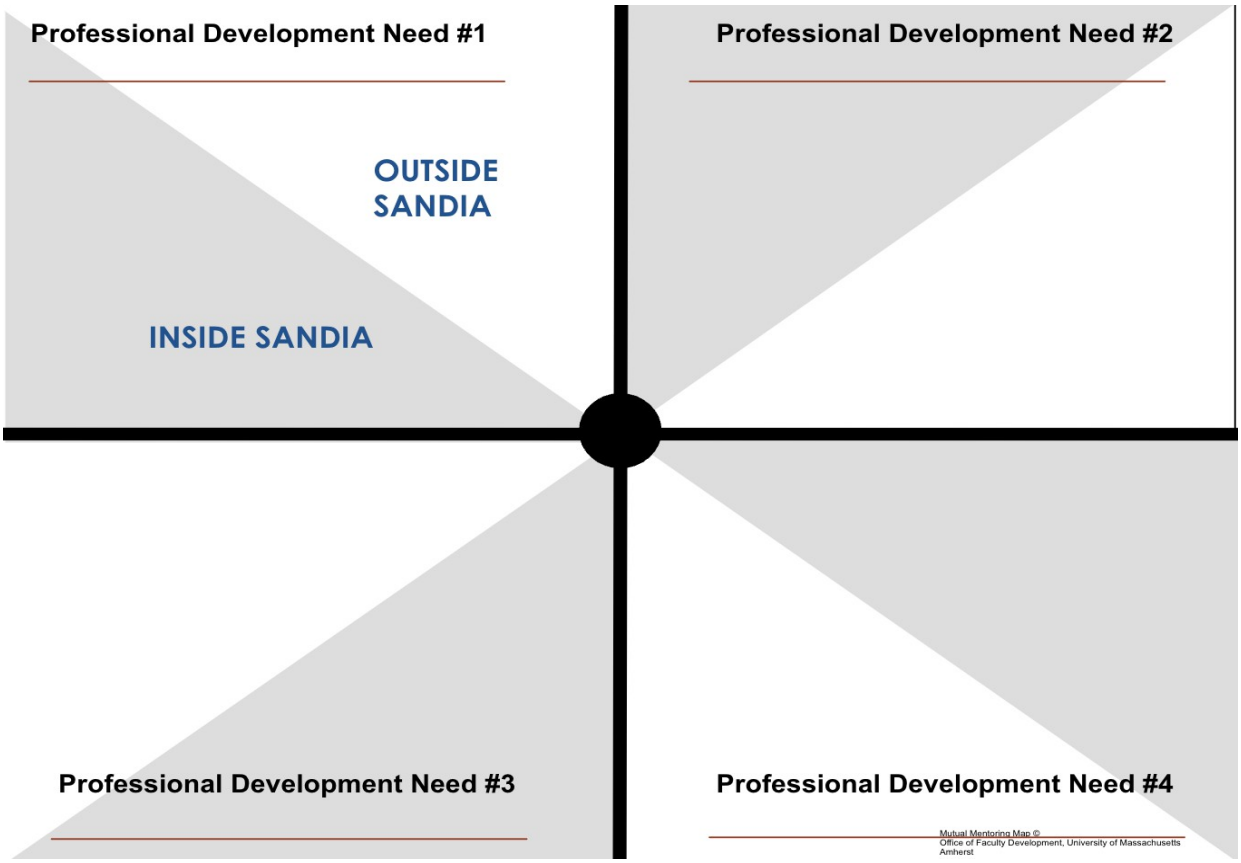
APPENDIX B. MENTOR MAPPING: PRIORITIZING YOUR MENTORING NEEDS

Domain of Postdoc Professional Development & Support (A) (examples)	Postdoc Need (B) ☑	Research Staff Ability or Interest (C) ☑	Technical Manager Ability or Interest (D) ☑	Other Individual or Department Ability or Interest (Specify) (E)
Research				
Data Analysis				
Grant Writing				
Laboratory Safety				
Research Design				
Authorship Norms				
Technical Skills				
Ethical Behavior & Responsible Conduct of Research				
Other				
Other				
Other				
Other				

Domain of Postdoc Professional Development & Support (A) (examples)	Postdoc Need (B) ☑	Research Staff Ability or Interest (C) ☑	Technical Manager Ability or Interest (D) ☑	Other Individual or Department Ability or Interest (Specify) (E)
Sponsorship				
Expand Networks with Funders and Sponsors				
Expand Networks with Scientific Collaborators				
Colleagues Advocating for the Interest of the Postdoc Internally to Sandia				
Identification of Opportunities for Professional Development				
Support for the Development of Independence (increased responsibility/ownership of research)				

Domain of Postdoc Professional Development & Support (A) (examples)	Postdoc Need (B) ☑	Research Staff Ability or Interest (C) ☑	Technical Manager Ability or Interest (D) ☑	Other Individual or Department Ability or Interest (Specify) (E)
Cultural Affirmation and Responsiveness				
Recognizing the Existence & Impact of Implicit or Explicit Bias in Science				
Build Self-Awareness of One's Own Sociocultural Values and How They Impact Their Behavior & How Others Engage with Them at Work				
Expand Proficiency with Communication with Individuals with a Range of Sociocultural Identities				
Increasing Access to Identity-Based Networks of Support				

Domain of Postdoc Professional Development & Support (A) (examples)	Postdoc Need (B) ☑	Research Staff Ability or Interest (C) ☑	Technical Manager Ability or Interest (D) ☑	Other Individual or Department Ability or Interest (Specify) (E)
Psychosocial & Career Support				
Self-Efficacy				
Science Identity				
Sense of Belonging				
Self-Confidence				
Motivation				
Communication				
Public Speaking				
Written Communication				
Oral Communication				
Communicating Science to the Public and to Policy-Makers				
Data Visualization				
Managing Difficult Conversations				


Professional Development Need #1
Professional Development Need #2
OUTSIDE SANDIA
INSIDE SANDIA
Professional Development Need #3
Professional Development Need #4
Mutual Mentoring Map ©
Office of Faculty Development, University of Massachusetts Amherst

APPENDIX C: RESOURCE PROVIDED DURING CIMER TRAINING

Proposed Attributes & Example Objectives for Improving Mentoring Relationships (Resource)

Adapted from Pfund C, Byars-Winston A, Branchaw J, Hurtado S, Eagan K. Defining Attributes and Metrics of Effective Research Mentoring Relationships. AIDS Behav. 2016 Sep;20 Suppl 2(Suppl 2):238-48. doi: 10.1007/s10461-016-1384-z. PMID: 27062425; PMCID: PMC4995122.

Attributes for Effective Mentoring Relationships	Example Measurable Learning Objective *Effective Mentors Can:*	Example Measurable Learning Objective *Effective Mentees Can:*
RESEARCH		
Developing disciplinary research skills	Teach mentees to design and carry out a research project; Provide opportunities to observe techniques	Develop the skills to design and carry out a research project;
Teaching and Learning disciplinary knowledge	Identify the knowledge mentees need to be successful in the discipline and guide them in learning that knowledge	Seek guidance from their mentors to identify the disciplinary knowledge they need and be receptive to mentor feedback that guides their learning
Developing technical skills	Provide instruction in core disciplinary research techniques	Commit to learning and gaining proficiency in disciplinary research techniques
Accurately assessing understanding of disciplinary knowledge and skills	Assess mentee learning of disciplinary knowledge and skills and provide feedback and guidance to address gaps	Self-assess learning of disciplinary knowledge and skills and respond to mentor feedback
Valuing the practice of ethical behavior and responsible conduct of research	Model the ethical conduct of research and actively engage in conversations with their mentees	Actively familiarize themselves with and follow ethical practices in their disciplinary research area
Developing mentee research self-efficacy	Foster mentees' internalization of their own research success	Effectively manage anxiety associated with independently conducting research

Attributes for Effective Mentoring Relationships	Example Measurable Learning Objective *Effective Mentors Can:*	Example Measurable Learning Objective *Effective Mentees Can:*
INTERPERSONAL		
Listening actively	Give their undivided attention and listen to both their mentees' words and the emotion behind the words	Give their undivided attention and listen to their mentors
Aligning mentor and mentee expectations	Establish and communicate mutual expectations for the mentoring relationship	Establish and communicate mutual expectations for the mentoring relationship
Building trusting relationships/ honesty	Offer honest and open feedback on how the relationship is progressing	Offer honest and open feedback on how the relationship is progressing

Attributes for Effective Mentoring Relationships	Example Measurable Learning Objective *Effective Mentors Can:*	Example Measurable Learning Objective *Effective Mentees Can:*
PSYCHOSOCIAL AND CAREER		
Providing motivation and facilitating coping efficacy	Scaffold research work in ways that yield periodic success; celebrate the successes and offer support after failures	Acknowledge that research frequently involves setbacks and develop strategies to deal with them
Developing mentee career self-efficacy	Foster and affirm mentees' career aspirations	Seek opportunities to explore and prepare for a career
Developing science identity	Recognize mentees as scientists	Affirm themselves as scientists
Developing a sense of belonging	Create a welcoming and inclusive research environment, especially at transition points	Actively engage and establish relationships with research team members

Attributes for Effective Mentoring Relationships	Example Measurable Learning Objective *Effective Mentors Can:*	Example Measurable Learning Objective *Effective Mentees Can:*
CULTURAL RESPONSIVITY		
Being culturally responsive	Effectively negotiate dialogue across diverse dimensions	Effectively negotiate dialogue across diverse dimensions
Reducing the impact of bias	Consider their unconscious biases and regularly check that they are not negatively impacting their own or their research team's behavior	Recognize unconscious bias, regularly check that it is not negatively impacting their behavior and address it when they observe it
Reducing the impact of stereotype threat	Recognize stereotypes that may negatively impact their mentees, acknowledge and work to reduce them	Recognize stereotypes associated with their group identity and address them to reduce potentially negative impacts

Attributes for Effective Mentoring Relationships	Example Measurable Learning Objective *Effective Mentors Can:*	Example Measurable Learning Objective *Effective Mentees Can:*
SPONSORSHIP		
Fostering independence	Continuously assess mentees' development and design increasingly challenging tasks and projects to advance mentees' independence	Push themselves to increase responsibility for and ownership of their research, while asking for support and guidance as needed
Promoting professional development	Identify opportunities for mentee professional development and support their engagement in them	Identify and engage in opportunities to develop the professional skills needed to become a successful scientist
Establishing and fostering mentee professional networks	Introduce and facilitate relationship building between their network of colleagues and their mentees	Actively identify and seek ways to meet and establish relationships with potential future colleagues in the discipline
Actively advocating	Promote mentees' work; Provide professional support	Report successful outcomes to mentor; Seek out and accept advocacy

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