Pacific Northwest
NATIONAL LABORATORY | Independent Oversight

Knowledge Transfer at Pacific Northwest National Laboratory (PNNL)

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Executive Summary

Workforce dynamics at Pacific Northwest National Laboratory (PNNL) necessitate a multi-faceted approach to establishing an effective, institution-wide knowledge transfer strategy. Key factors underscoring this need include Laboratory growth, retirement-eligible workforce trends, competition for talent, and career expectations of staff. These factors combine to create a dynamic environment in which continuing turnover across the workforce is inevitable. A critical aspect of this strategy requires engagement with line management to assure business needs are addressed while simultaneously addressing workforce expectations.

PNNL's Independent Oversight (IO) Office led an assessment of the effectiveness of the Laboratory's knowledge transfer practices. The current state of knowledge transfer encompasses both positive practices with several organizations already taking steps to address their knowledge transfer needs and areas of institutional opportunity. High-level summary conclusions include the following:

- Knowledge transfer is a critical element affecting the Laboratory's ability to safely and effectively execute PNNL's mission.
- PNNL does not have an institutional approach to assure we consistently and effectively perform knowledge transfer.
- A management and operations program (M&OP) should own the overall practice, define PNNL's knowledge transfer approach, maintain responsibility for supporting tools, and monitor performance for assurance that practices are working as intended.

Several examples of current knowledge transfer practices include the following:

- Transition plans developed by several senior PNNL leaders to support the onboarding of successors.
- Project Management Office Directors (PMODs) identifying potential succession candidates, delegating authorities to these candidates when the PMOD is out of the office and including them in project decision-making meetings.
- An ongoing knowledge transfer pilot effort in the Operational Systems Directorate (OSD) to assure directorate operations and activities can be effectively sustained during periods of transition.
- Mentoring and rotational assignments to broaden the experience baseline of existing staff.

The benefit of these activities is limited by the fact they are generally ad hoc and have not been incorporated into a broader framework that could be templated for use across the entirety of PNNL. Noted knowledge transfer gaps identified in this assessment include:

- Weaknesses in division-, group-, or team-level (defined as "local") onboarding practices that do not provide new staff with the catalog of explicit and implicit knowledge needed to fully acclimate to their new role.
- Inconsistent application of mentoring opportunities, succession planning, and offboarding processes that limit the positive impact that these approaches can provide.
- Incomplete onboarding of external hires for senior management positions who are not provided with the necessary implicit information essential to an effective transition.
- The lack of a systematic approach/strategy for transitioning experienced staff who conduct complex operations.

Accordingly, a success-oriented path forward should be guided by a number of principles, including the following:

- For knowledge transfer to be successful, it needs to be seen as a cultural expectation and a way of doing business.
- Ultimately, there needs to be "committed intent," defined as clearly established accountabilities, specific actions taken, and assurance that intended actions are delivering results.
- There should be a graded approach to knowledge transfer, and to the greatest extent possible, it should be incorporated into existing processes in order to manage cost and effort.
- Primary responsibility for knowledge transfer lies with line management (for all staff), project management (for projects), and the staff themselves. HR has a critical role in supporting the future of the Laboratory's knowledge transfer efforts.

Acronyms

AI	Artificial Intelligence
ALD	Associate Laboratory Director
CoP	Community of Practice
DOE	Department of Energy
HDI	How Do I?
HR	Human Resources
IO	Independent Oversight
LLT	Laboratory Leadership Team
M&OP	Management and Operations Program
ORNL	Oak Ridge National Laboratory
OSD	Operational Systems Directorate
PMOD	Project Management Office Director
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
R2A2s	Roles, Responsibilities, Accountabilities, and Authorities
SME	Subject Matter Expert

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Introduction

Knowledge transfer is a mechanism that Pacific Northwest National Laboratory (PNNL) can use to assure that essential information related to the execution of job functions—i.e., skills, abilities, competencies, and governing processes—are captured, implemented, and managed in a manner such that Laboratory operations and activities can be effectively sustained during staff transition(s).

There are two types of knowledge transfer. The first, known as "explicit knowledge," refers to knowledge that can be easily articulated, formalized, and documented. Explicit knowledge is often found in back-office procedures, manuals, guides, documents, reports, records, and databases. In contrast, "tacit and implicit knowledge" is informal and intangible knowledge that people acquire through personal experience, skills, networks, and perspectives. This type of knowledge generally requires personal contact, interaction, observation, and trust, and is often revealed through social networks, communities of practice (CoPs), and interviews (see Figure 1).

The connection between explicit and implicit knowledge transfer is intertwined with onboarding and offboarding activities. While explicit knowledge facilitates a structured approach, implicit knowledge brings the depth of experience and skills necessary for employee integration and growth. For example, during the onboarding process, organizations seek to transfer both explicit and implicit knowledge to new employees. Explicit knowledge is often imparted through training sessions, orientation programs, and instructional materials. This includes sharing documented procedures, policies, best practices, and company culture. Implicit knowledge, which is more challenging to transfer, is often shared through socialization, mentorship, work observation, and job shadowing experiences. By combining explicit and implicit knowledge transfer, organizations can effectively integrate new employees into their work environment.

Offboarding activities involve the departure of employees, making knowledge transfer crucial for organizational continuity. Explicit knowledge

Figure 1. Knowledge transfer include explicit and implicit knowledge[1]

transfer at this stage includes preserving and documenting employees' expertise, project-related information, and intellectual property. This assures that valuable knowledge is not lost when employees leave. Additionally, offboarding offers an opportunity for implicit knowledge transfer via departing employees sharing their experiences, lessons learned, and unique insights. Organizations can facilitate this transfer by conducting exit interviews, encouraging knowledge-sharing sessions, and documenting personal reflections via interviews (written and/or videos).

This assessment was conducted to provide insight into the different modes of knowledge transfer across PNNL and, by doing so, to

- Identify where knowledge transfer practices are most important (through one's career lifecycle).
- Identify implementations to knowledge transfer methods and practices.
- Address knowledge transfer use cases that help illustrate key career development steps.

[1] Concept taken from https://nix-united.com.

Importance of this Assessment

In an era of high staff turnover and retirements, knowledge loss has become a pressing concern at PNNL. Assessing the Laboratory's knowledge transfer practices enables sharing of good practices and identifying process gaps that could affect knowledge areas that may be at risk of being lost.

Organizations often face the challenge of knowledge silos, where information and expertise are confined within specific work groups or a small number of individuals. By assessing knowledge transfer practices, organizations can identify and manage these silos and implement strategies to bridge knowledge gaps. This may involve knowledge sharing platforms or sharing knowledge transfer best practices between different directorates or divisions. By consistently evaluating and improving the knowledge transfer processes and integrating these into how the Laboratory conducts its business, organizations can build a knowledge-driven culture and achieve greater sustainability, especially during times of rapid staff growth and departures.

Assessment Participants and Methodologies

This assessment was conducted in two phases, as described below.

Phase I

- Interviews were held with various PNNL and Pacific Northwest Site Office (PNSO) staff including associate laboratory directors, division directors, Laboratory Fellows, Project Management Office Directors (PMODs), group leaders, individual contributors, Management and Operations Program (M&OP) managers, and PNSO staff. There were approximately 70 interviews with engagements spanning staff that were recently hired, those who had changed positions within the past 12 months, and those who have longevity in their role.
- High-level summary analyses were conducted to determine the percentage of new staff during the fiscal year, staff transitions over the past year, and staff turnover during the past five years.
- The Independent Oversight (IO) assessment team conducted a literature search to identify knowledge transfer models and best practices that can be used by knowledge transfer practitioners in developing roadmaps for knowledge transfer efforts.

Phase II

During the second phase of this assessment, the IO assessment team met with senior-level groups, including the Laboratory's chief operating officers, the Division Director Forum, the PMOD Forum, and M&OP managers to gain collective insights and to identify gaps. The total number of PNNL managers interviewed as a part of this effort was 64. Their collective responses are reflected in the observations and outcomes of this IO assessment.

This assessment captured good practices and opportunities for improvement for consideration by PNNL's Laboratory Leadership Team (LLT).

Assessment Results

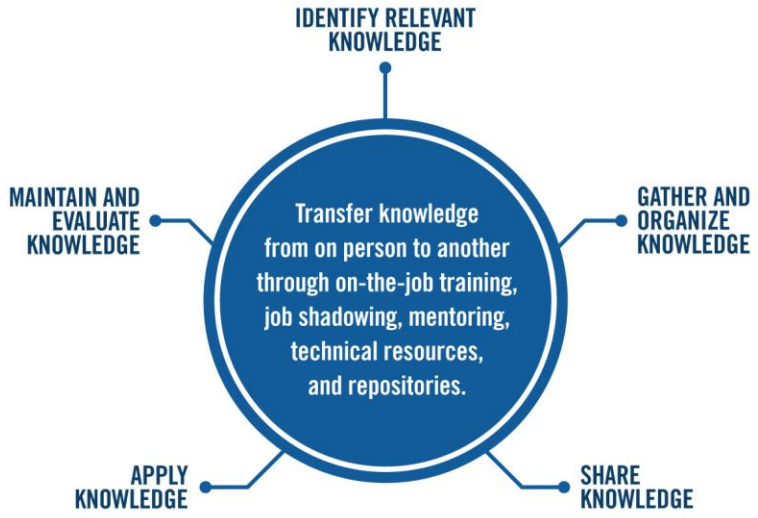
Knowledge transfer is the process of sharing, disseminating, and applying information or experiences from one individual or organization to another. Underlying knowledge transfer are a set of principles that are essential for establishing effective knowledge-sharing practices. Recognizing and embracing knowledge transfer principles propels the organization forward by assuring efficient and effective transfer of expertise, experiences, and ideas.

Guiding principles for knowledge transfer include the following:

- Intentional – Performed as a way of doing business.
- Strategic – Emphasizes areas of knowledge transfer essential to effective operations.
- Holistic – Involves explicit and implicit knowledge across all jobs.
- Shared responsibility – Requires intent and execution on the part of the line management, project management, and staff.
- Focused – Concentrates on knowledge essential to jobs, critical operations, and career progression.
- Continuous – Includes knowledge transfer at various stages, including onboarding, cross-boarding (internal job changes), and offboarding.

Knowledge Transfer Framework

A well-designed knowledge transfer framework should be logical, scalable, and easy to implement. Examination of the literature identified a number of idealized knowledge transfer frameworks. A compilation of steps developed by the IO assessment team is shown in Figure 2. This systematic configuration is the goal of a knowledge transfer process.



1. **Identify** important knowledge that exists within the organization through examining existing documents, interviewing employees, and conducting surveys.
2. **Gather and organize** knowledge and document in a way that makes the information easily accessible to employees for their use (e.g., databases, wikis, or knowledge bases).
3. **Share** knowledge with the staff and stakeholders through person-to-person interactions. Other means to support these interactions include training programs and collaboration tools.
4. **Apply** knowledge to improve organizational performance such as process improvements and science and technology innovation.
5. **Maintain and evaluate** knowledge to assure its relevance and accuracy (e.g., regular reviews, updates to knowledge management systems, or ongoing training programs).

Figure 2. Knowledge transfer framework

The following sections of this report assess current knowledge transfer practices at PNNL and based on this information. This material is presented in four use cases, as identified below.

Use Cases – The Assessment

Because the Laboratory does not have an institutionalized knowledge transfer process in place, an evaluation approach was developed by the IO assessment team so that knowledge transfer methods, risks, and best practices at PNNL could be evaluated systematically and uniformly.

The IO assessment team created the following seven questions to assess the current state of knowledge transfer at PNNL:

1. What types of knowledge need to be successfully captured?
2. How is knowledge at PNNL currently captured, transferred, and shared?
3. How is this knowledge being applied and used?
4. What gaps emerge when knowledge transfer practices are not in place?
5. Where are there gaps?
6. What can be done to mitigate these gaps in the future?
7. What good practices did the team hear?

These seven questions were applied to four use cases: 1) day-to-day work activities, 2) career development, 3) executive leadership, and 4) critical operations. These use cases, their definition, and the gaps associated with each are provided in Table 1 below.

Note that these use cases are not intended to cover all potential scenarios for knowledge transfer at PNNL, but rather illustrate how the Laboratory could implement a knowledge transfer strategy that would encompass these different circumstances.

Table 1. Defined use cases

USE CASE	DEFINITION
Day-to-day Work	The explicit knowledge needed for staff to succeed in their day-to-day work tasks
Career Development	Implicit and non-technical knowledge that goes beyond day-to-day work and is necessary to successfully interface with sponsors, influence outcomes, win proposals, and build networks
Executive Leadership	Implicit knowledge necessary for successful transition to executive positions
Critical Operations	Explicit knowledge needed to understand critical operations and manage operational risks

Use Case 1 – Day-to-Day Job Work

An employee's day-to-day job skills rely on explicit knowledge as a starting point (i.e., knowledge that can be codified in procedures, manuals, guides, plans, and other documents and is easily shared among co-workers). In this use case, staff early in their career may be largely dependent on knowledge that allows for systematic learning and skill development, both in research and mission support jobs. For staff that are in their mid- to late-career, day-to-day tasks rely more on networks and implicit means of knowledge transfer. While there is no institutionally standardized approach at PNNL for capturing explicit knowledge across the Laboratory, there are some notable good practices going on in some directorates, as identified below:

- Individualized transition plans have been developed for incoming staff, whether they are new to the Laboratory or to a position.
- Most organizations emphasize internal networking as important to the success of one's career and maintain lists for staff to talk to.
- Updated roles, responsibilities, accountabilities, and authorities (R2A2s) that help staff understand expectations and access to documents, guides, procedures, and files that support current work activities.
- Creating templates and instructions for use in report development, assessments, causals, and other activities.
- Sending staff to trainings that reinforce the necessary skills-based competencies to do the job and, in turn, increase the capabilities of the group or team.
- Funded internship programs help interns navigate the Laboratory, understand how to engage in projects that they support, and develop networks for current and future use.
- User groups, CoPs, and technical forums that communicate and document Laboratory practices and help new staff build knowledge, skills, and networks in their jobs.
- Providing new staff with a mentor who is a reference point for domain knowledge and tasks.

This assessment observed that explicit knowledge is often captured in an ad hoc manner with some organizations implementing a knowledge management system that can be accessed to help staff. In most organizations, however, no structured approach exists. Feedback on gaps identified during the assessment included the following:

- Local onboarding at the directorate, division, group, or team level is often dependent on the new staff member taking the initiative to understand their job and their role within it (without direction). For example, it is not always clear what interns or early career staff are expected to do when they begin work. This is exacerbated by the number of new staff who may not have the appropriate history or backup procedures, guides, and templates to help guide in the work that they will be doing.
- Mentoring, a critical success factor for new hires, is too often constrained by time and resources. Many senior staff, particularly those in demanding fields, struggle to allocate sufficient time for mentoring due to their own commitments. In addition, some funding constraints were noted to restrict the availability of mentoring opportunities, hindering the implementation of comprehensive mentoring programs.
- Offboarding is inconsistent in terms of assuring an effective transition (overlap), and adequate succession planning is missing for most positions.
- Networking outside of one's immediate team, a critical component for understanding the Laboratory and key positions that a staff member needs to interface with, is often delayed or does not exist.

Use Case 2 – Career Development

World-leading staff in research and operations are the foundation of a national laboratory. As such, all staff should aspire to build on their expertise throughout their career with the potential to evolve into the technical experts, operations professionals, and impactful leaders of tomorrow.

Career development is a sustained, multi-year process that requires staff to continuously acquire and apply new knowledge and skills, adapt to changing work environments, and take advantage of special assignments that demonstrate leadership qualities. There are several key factors associated with knowledge transfer that contribute to effective career development:

- *Acquiring and applying knowledge* forms the foundation of career development. Acquiring knowledge involves obtaining relevant information, skills, and expertise required for professional growth. Interviews identified several noted knowledge transfer efforts that support acquiring knowledge, including taking what is learned from formal educational opportunities and applying them to a project task or group effort, engaging in training and development programs, and applying what is learned through Laboratory initiatives and community-based projects. To be successful, staff need to be able to apply the knowledge they acquire to strengthen practices or solve problems of importance to the Laboratory.
- *Mentoring, peer partnering, and collaboration* play pivotal roles in knowledge transfer and career development. Engaging in mentorship programs (throughout one's career) and/or seeking guidance from experienced professionals (or peer partners) was described as heightening one's learning curve. The shared experiences and insights provided by mentors that participate in PNNL's mentoring program are helping our staff gain a deeper understanding of the Laboratory, and when applied to their specific field, enable staff to make informed decisions and set realistic career goals. Providing staff with a peer partner who is a reference point for domain knowledge, has access to tribal knowledge, and can share "tricks of the trade" was viewed as particularly helpful. Additional collaborative work environments through project activities foster knowledge exchange among colleagues, encouraging mutual growth and skill enhancement.
- *Networking and developing relationships* was cited by interviewees as essential for career development at the Laboratory. Building relationships through networking provides staff with the opportunity to connect with sponsors and build professional collaboration with staff at other institutions, including through CoPs across Battelle-affiliated laboratories. In addition, by attending conferences, seminars, and other professional activities, staff gain exposure to diverse perspectives and valuable knowledge.
- A commitment to ongoing *professional development* results in enhancing a staff member's existing skills and facilitates the acquisition of new knowledge. Several good practices were noted through interviews, including PMODs who offer potential succession candidates the opportunity to participate in project review activities and Laboratory Fellows who invite junior staff to observe decision-making meetings. Other examples include attending workshops, pursuing advanced certifications, and engaging in self-directed learning. These activities are a part of the Laboratory's expectations for research staff and could be strengthened in parts of PNNL's mission support organizations where it's equally germane to staff growth and development.

All the above requires a shared responsibility for execution on the part of the line management, project management, and staff when onboarding, cross-boarding (internal job changes), and offboarding staff. Given the expected duration of a career and what constitutes successful knowledge transfer, these elements must be sustained over a significant period of time. The following knowledge transfer gaps were identified that could be strengthened at PNNL:

- The effectiveness with which knowledge is transferred essentially is driven by individual managers (as opposed to an institutional approach accompanied by a set of practices) and can negatively impact opportunities for staff whose management does not recognize the importance of or engage in knowledge transfer efforts. As these staff mature in their positions,

they have a much higher likelihood of leaving for better opportunities where management is supportive of their career.

- While there are exceptions, PNNL does not consistently assure that staff are effectively prepared to take on assignments with increasing responsibility.
- The utility and value of leadership and development training (e.g., Lead, Engage, and Develop Staff [LEADS]; Advancing Manager Pathways [AMP]; Scientist and Engineer Rising Leaders; and Pre-Executive Learning Journey [PELJ]) is high. These also provide for excellent networking opportunities across PNNL. It was noted that these career development programs are selective with limited availability and leave most staff to try and figure it out on their own.
- Significant involvement and leadership in external technical societies is necessary for career progression; however, these professional society activities are not always well-supported by management.
- In terms of career development opportunities, interviewees identified that a better understanding of how the Laboratory operates, how one's organization fits within the overall organization at PNNL, and how the work conducted fits within the Laboratory's strategy would be helpful to inform decision-making around career path direction.
- Implicit knowledge—i.e., experiences, perspective, insights, mental models—becomes increasingly important with career progression. Capturing this information is often missing as a part of local offboarding practices when staff retire (or leave).

Table 2. Career progression and knowledge transfer steps

CAREER STAGE	SUMMARY
Early Career	**Acquiring knowledge:** Strong foundation in technical field/operational discipline, understanding how PNNL operates, understanding of project lifecycle, ability to collaborate with others, and proposal development. **Applying knowledge:** Support project work, establish networks, and establish the technical or operational expertise. **Knowledge transfer:** Mentoring, peer partnering, coaching, R2A2s, processes and procedures, PNNL-specific training, external training, and verbal and written communications with other staff.
Mid-Career	**Acquiring knowledge:** Broader domain expertise, understanding relationship management, understanding project management, and business development skills. **Applying knowledge:** Expand technical and project roles, increase leadership skills, and increase sponsor engagement. **Knowledge transfer:** Similar to early-career staff plus formal and informal succession planning.
Late Career	**Acquiring and applying knowledge:** Mastery of technical and project success, domain leadership and mentorship/development of other staff, engagement with sponsor leadership and maturing of sponsor relationships, program management, research climate and business development. **Knowledge transfer:** Formalized succession planning, which is inconsistent.

Use Case 3 – Executive Leadership

Executive and senior leaders hold unique positions within PNNL and are instrumental in shaping the Laboratory's organizational culture, determining its strategic direction, and setting performance expectations for staff. As such, an executive's understanding of how the Laboratory is structured and operates directly affects their ability to fulfill their individual and organization's responsibilities. Without this understanding, the newly designated leader will face delays in providing the anticipated strategic decisions and contributions expected of their position.

Knowledge transfer is an important process that supports the transition of an executive or senior leader into their new role. Examples of knowledge transfer mechanisms span those that support onboarding to offboarding and include mentoring, and executive coaching, documenting specific R2A2s, maintaining up-to-date operating procedures, executive training and coaching (development), stewarding CoPs, and succession planning. Feedback from executive and senior leaders on PNNL's knowledge transfer processes included the following:

- Knowledge transfer for PNNL executives is largely informal and unstructured when it occurs. There is heavy reliance on the knowledge and skills one brings to the position. The IO assessment team noted a trend that the more senior the position, the less likely knowledge transfer occurs (implicit information is usually what the executive needs, but explicit information is often missing, as well).
- Onboarding of external executives and senior leaders should include an introduction to the Department of Energy (DOE) laboratory system, its origins, and current purpose and impact. This helps assure alignment with the PNNL contract and appreciation for a national laboratory's conduct of operations.
- In order for executives and senior leaders to put their job description, R2A2s, and goals for their individual performance into context, they first need to understand how the Laboratory operates and how the organization they lead fits into the enterprise. This information is described at a high level in the PNNL Operating Model program description (available in How Do I? [HDI]). External hires typically need a prompt to find the description and then rely on members of their management teams to answer questions. Perhaps more importantly, an orientation to the Operating Model would be useful, especially for external hires.
- At the executive level, external hires are assigned one or two executive peer "buddies" (one from Research and the other from Management and Operations) to help orient them to the Laboratory and the LLT's norms and practices. These are informal, self-directed activities. This practice is not used for internal promotions, as the person promoted has often been a delegate and has had some exposure to how the LLT operates. Even so, those promoted executives said they would have benefitted from having a peer buddy.

Several knowledge transfer good practices were described by the interviewees and include the following:

- In cases where the predecessor was not available to help the incoming leader navigate the transition, the predecessor prepared a transition memo describing unwritten or implicit expectations, key internal and sponsor relationships, risks and pitfalls to avoid, and various tips of the trade. Those who received such information found them invaluable and referred to them months and years later.
- Senior staff work through networks. As relationships accumulate, success can be as much about relationship building as knowledge transfer. Deemed essential for success, one directorate's chief operating officer created a roadmap of people to contact and network with.
- Some organizations have become tight knit over time, usually because leadership has intentionally rotated staff for career growth and development. Under the principle that "once you have a job, you never really leave it," people who depart the directorate or the Laboratory know they are only a phone call way. They feel loyalty and a connection to PNNL and are willing to answer questions about past events and practices. Although this tribal knowledge is

rarely captured in documentation, it can result in significant time-savings to the learning curve of new designated leaders.

- Another effective practice was for the outgoing leader to share “war stories” in an open-invitation meeting with colleagues. Storytelling is durable knowledge-transfer technique. Stories are personal, memorable, and teach agency that transcends the job.
- Two other knowledge transfer techniques were lauded by interviewees. The first is to invite staff, especially succession candidates, to “ride along” to meetings, mainly as observers. After the meeting, the leader elicits information, such as what did you hear, what did you learn, what questions do you have? This helps reinforce the capture and transmittal of historical decision-making and is especially helpful in exposing incoming leaders to board governance activities.

Use Case 4 – Critical Operations

Critical operations encompass a wide range of potential hazards that organizations face in their day-to-day operations. Such operations require careful consideration and proactive management to protect business continuity and sustainability.

Knowledge transfer plays an important role in effectively managing critical operations. By disseminating best practices, lessons learned, and capturing information on past experiences, organizations can prevent the recurrence of mistakes and minimize the likelihood of operational failures. Capturing explicit information through documents and procedures, as well as implicit knowledge (experience and critical know-how) from experienced staff helps mitigate the risks associated with staff turnover and retirements of those personnel who conduct these types of operations. In addition, the transfer of knowledge regarding compliance, safety protocols, and regulatory requirements help to mitigate the risk of non-compliance and associated consequences in critical operations.

Despite the benefits of knowledge transfer, organizations often face several challenges that impede effective implementation, including lack of knowledge-sharing, resistance to change, and poor communications. Overcoming these barriers requires a proactive approach involving management support, (targeted) training programs, knowledge-sharing activities or initiatives, and integrating user-friendly knowledge management systems. Feedback from interviews included the following:

- Job shadowing allows for staff to observe operations, ask questions of those performing the work, and review documentation related to the work to obtain familiarity with the operation prior to performance.
- Mentoring provides staff with a point of contact for questions, insights on where to locate historical data and documentation, and access to a broader network of resources. Similarly, peer partnering supports knowledge transfer between staff.
- Hiring proactively, when possible, assures incoming staff have adequate time with their predecessor for mentoring and job shadowing.
- Discussions of operational past performance and lessons learned are more easily understood during performance of the operation.
- Rotating staff through multiple positions in an organization helps build bench strength and can aid in keeping documentation current for operations.

Weaknesses identified during the assessment that inhibit successful knowledge transfer of critical operations include the following:

- Lack of predecessor transition for critical operations, either because the predecessor has left PNNL, or the operation is performed so infrequently that it transcends multiple careers. This includes once-in-a-generation activities that have multiple risks related to knowledge transfer, including attrition of staff that have previously performed the task, lack or loss of documentation on the task, uncertainty regarding latent conditions, and accuracy of historical as-built drawings.
- Insufficient bench depth, either due to staff attrition or funding constraints prohibiting cross-training for retention of key information.
- Lack of robust documentation leading to historical decision-making not captured and retained for reference can cause confusion and result in potentially repeating past mistakes.

Risks

If knowledge transfer methods and processes are not effectively applied, possible outcomes can potentially include 1) ineffective local onboarding, 2) loss of key information or knowledge, 3) delays in filling critical positions, 4) inconsistent succession planning, and 5) staff frustration potentially leading to departures (see Figure 6). These outcomes will, in turn, produce potentially significant risks to PNNL, as described below. Ultimately, "knowledge" is a strategic asset that, if managed ineffectively, can have profound impacts.

- **Organizational performance decreases.** When key information is not transferred or its lost and critical positions are not filled in a timely manner, the "institutional memory" is negatively impacted. Combined with ineffective local onboarding, collaboration is weakened, and decision-making can be less effective, leading to reduced performance.
- **Productivity declines.** When local onboarding is ineffective, the time it takes for new personnel to be fully effective in their job is extended. If the transition between incoming new staff and their predecessor is insufficient, conditions could lead to the need to "reinvent" previously existing decision rules, information, and processes. Duplicative work and errors can result. Sponsor deadlines, milestones, and deliverables can be impacted.
- **Creating knowledge silos.** Organizations often face the challenge of knowledge silos, where individuals possess specialized knowledge that is not shared with others. This leads to information gaps, inefficiencies, and potential disruption when key staff leave the organization. Knowledge transfer efforts can mitigate this risk by actively promoting knowledge sharing, documenting best practices, and creating formalized processes. This assures that critical knowledge is retained within the organization, enabling a smooth transition during staff changes and maintaining operational continuity.
- **Talent development limited.** Effectively sustaining the organization demands that expectations are made clear, opportunities are presented to the workforce, individuals develop and advance, and the workforce is replenished. Each of the elements of this cycle must perform optimally for these outcomes to be achieved. When onboarding the workforce is limited in effect, critical information may be lost or not transferred, and the transition between predecessor and successor does not achieve the desired objectives. As a result, the Laboratory is not able to fully leverage the potential of the organization's workforce. These conditions can confine critical knowledge to a fewer number of individuals, resulting in the creation of knowledge gaps and limiting opportunities for others.

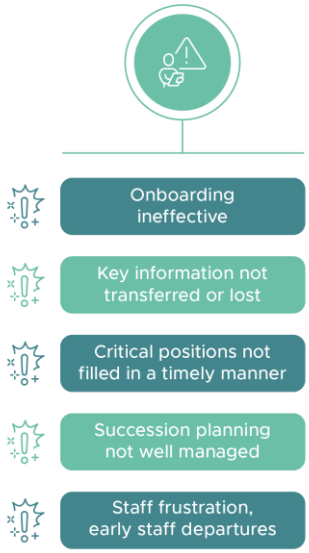


Figure 3. Knowledge transfer weaknesses

- **Compromised safety, security, and compliance.** Compliance with requirements demands that personnel understand and embrace Laboratory values related to safety and security performance. These principles are most effectively conveyed through discussions and demonstrated behaviors. Conditions that "break this chain" (e.g., ineffective local onboarding, loss of key information/knowledge, delays in filling critical positions, and inconsistent succession planning) can impact the Laboratory's compliance posture.

Appendix A. Assessment Team Biosketches

Bob McCallum (McCallum-Turner Maryland, Inc.)

Bob McCallum has more than 32 years of experience in developing and managing multidisciplinary projects in energy technology areas. He has directed projects that include safety, health, environmental, and management reviews of DOE facilities; development of guidance documentation related to nuclear power plant licensing, examination of system impacts of nuclear waste management technology options; evaluations of site alternatives for waste storage and disposal systems; and preparation of National Environmental Policy Act compliance documents for major actions. Bob has conducted reviews of the effectiveness of organizations and specific functions or systems, developed recommendations for improving organizational performance, and has designed strategies for launching new organizations and organizational constructs. Bob has evaluated the effectiveness of work planning and control systems for research and development activities and maintenance and operations functions and has evaluated existing assessment processes and systems as mechanisms to improve organizational performance. He holds a BS in civil engineering from the University of Massachusetts, Lowell, and an MS in management from Purdue University.

Nico Branderhorst (PNNL)

Nico Branderhorst is an HR strategist who partners with executive-level business leaders to forecast, plan, and execute on their business's HR priorities. Prior to joining PNNL as the HR strategic partner for the Energy and Environment Directorate, Nico spent over seven years supporting multi-billion-dollar businesses in the distribution segment, as well as consulting for small businesses. During that time, Nico has gained experience in transformation and change management, project management, business strategy, labor relations, talent development, and workforce planning. Nico holds a BS in HR management from Portland State University and an MBA with a concentration in finance and HR from the University of Illinois.

Joe Burks (formerly PNNL)

Joe Burks is currently the Business and Contracts Manager for Inomedic Health Applications, Inc., and a member of the executive team. He was previously a staff member with PNNL from 2005 through 2023. His experience includes over eight years in the Office of General Counsel as an attorney providing legal advice and business support to PNNL's Business Services Directorate and the Acquisitions Management organization. He also served as a legal advisor on various matters such as Laboratory operations, risk management, national security, export control, conflicts of interest, and ethics. Joe was also in the PNNL Contracts organization from 2005 through 2015 and served as a senior contracts specialist and the Acquisitions M&OP manager. Joe has a law degree from Willamette University College of Law (2001) and a bachelor's degree in business from Linfield College (1998).

Pam Hughes (PNNL)

Pam Hughes manages the PNNL IO Office and is responsible for the planning and management of IO assessments to determine the efficiency, effectiveness, and adequacy of PNNL's systems, operations, programs, and processes. Pam previously managed PNNL's planning function, where new capabilities associated with scenario planning and multiyear planning were developed and implemented. Prior experience includes leading PNNL's institutional science and technology performance under the Office of the Deputy Director for Science and Technology, where new standards for PNNL-level performance were developed and deployed. She managed PNNL's Laboratory Directed Research and Development program and instituted PNNL's science and technology investment process for major capability development initiatives. She developed and implemented technical review processes; trained with Conger and Elsea, Inc., on causal analysis; and has been involved in operational assessments. She has authored and coauthored several internal publications and several white papers on peer review for DOE, as well as on science and technology performance. Her undergraduate degree is in social sciences and biology from Washington State University, and she completed two years of graduate course work in neurophysiology.

Ray Klann, PhD (PNNL)

Dr. Raymond Klann is a senior physicist at PNNL with 32 years of experience within the DOE national laboratory system. He is currently the Detection Science leader for the Department of Homeland Security (DHS) Countering Weapons of Mass Destruction Office's Large-Scale Equipment Acquisition and Deployment Program. Previously, he served as the division director for the Signature Sciences and Technology Division and, prior to that, as the group leader of the Applied Radiation Detection group focused on the development of radiation detection technologies supporting applied measurements in nuclear emergency response, border security, treaty verification, and other U.S. government objectives. Raymond has experience in radiation detector development and testing and algorithm development for radiological search and nuclear interdiction. His area of expertise is in experimental nuclear techniques, nuclear measurements, radiation transport analysis, and reactor physics. He has been a lead test scientist for the DHS Countering Weapons of Mass Destruction Office, an assessment scientist for the DOE Radiological Assistance program, a program area leader for Render-Safe Technologies for the Nuclear Incident Response program, as well as a member of the science team for the Nuclear Smuggling Detection and Deterrence program. Before joining PNNL, Raymond spent 23 years at Argonne National Laboratory as the manager of the Radiological Detection and Response section of the Nuclear Engineering division. Raymond holds a PhD in nuclear science and engineering from Idaho State University, as well as a BS and MS in nuclear engineering from the Massachusetts Institute of Technology. He has over 120 reviewed publications and reports, along with 6 U.S. patents.

Carolynn Novich (PNNL)

Carolynn Novich is the special assistant to the laboratory director and a member of the LLT. She serves as a confidential advisor in setting priorities, developing strategies, and advancing the director's institutional agenda through engagements with sponsors, stakeholders, senior leaders, and staff. Her background includes technical communications, strategic planning, and project management. She began her career at PNNL as a technical writer, focusing on environmental programs and project management oversight, before joining PNNL's Office of Strategic Projects, where she prepared strategic and business plans to incubate major new research and development programs. Carolynn serves as secretary of the PNWD Board's Institutional Strategy, Science and Technology Committee and supports a variety of corporate governance activities. She has an undergraduate degree from Washington State University.

Parans Paranthaman, PhD (Oak Ridge National Laboratory [ORNL])

Dr. Parans Paranthaman is a Corporate Fellow in the Chemical Sciences Division at ORNL. Parans is also a fellow of the National Academy of Inventors, Materials Research Society, American Association for the Advancement of Science, American Physical Society, American Ceramic Society, ASM International, and the Institute of Physics, London, UK. He earned his PhD in materials science and solid-state chemistry from the Indian Institute of Technology, Madras. He was a Postdoctoral Fellow with 2019 Chemistry Nobel prize winner Professor John Goodenough at the University of Texas, Austin, and a research associate with Professor Allen Hermann at University of Colorado, Boulder. He joined the Chemistry Department at ORNL in May 1993. He has authored or co-authored more than 446 journal publications and has a total of over 90 inventions, including 58 issued U.S. patents related to his research. He has licensed his technologies to eight industries for commercialization. His present research focuses on the Development of Additive Manufacturing of N95 Fabrics and Antiviral Coatings, Additive Manufacturing of Permanent Magnets and Motors, Lithium Separation from Geothermal Brine, Recovery of Carbon from Recycled Tires for Clean Energy Applications, and Development of Electrode Materials for Energy Storage Applications.

Reid Peterson, PhD (PNNL)

Dr. Reid Peterson is currently the team leader for the Process Sensing and Separations team of 12 chemists and engineers working on issues associated with separations and monitoring for nuclear materials processing. Reid's research is primarily in the field of waste processing for treatment of high-level waste. In particular, Reid's research has focused on filtration, ion exchange, and process scale up. Through his past work at the Hanford Waste Treatment Plant and Savannah River National Laboratory (SRNL), Reid has developed working relationships with

key staff across the DOE national laboratory system, including Argonne National Laboratory, Idaho National Laboratory, Los Alamos National Laboratory, and SRNL, as well as site contractors for waste processing at both Savannah River Site and Hanford.

Chris Ross (PNNL)

Christine Ross is a project manager at PNNL with 25 years of experience at Battelle Memorial Institute and PNNL. She is currently the Non-Nuclear Readiness program manager and leader for OSD's Strategic Workforce Management Plan. Her area of expertise is in facility readiness and knowledge transfer. Her previous experience was as a leader for several knowledge management efforts for various clients such as DOE, U.S. Nuclear Regulatory Commission, U.S. Army Office of Energy Initiatives, and the Defense Logistics Agency. Chris holds a BA in social sciences from Washington State University.

Pete Stromberg (PNNL)

Pete Stromberg is the training support manager at PNNL. He has over 40 years of experience in the learning and development field with various DOE (PNNL and Bechtel), Department of Defense (McDonnell Douglas and AAI Corporation), and non-affiliated organizations in the commercial aviation (United Airlines), energy (Chevron), and financial services (Lehman Brothers and Solarity Credit Union) industries. He has a bachelor's degree in organizational development, master's degrees in organizational leadership and in human resources management and is a Society of Human Resources Management senior certified professional. He proudly served in the United States Army.

Katrina Walker, PhD (PNNL)

Dr. Katrina Walker manages the Facilities Management M&OP and is responsible for the identification and implementation of contractual requirements. Katrina previously managed the Nuclear Training program, assuring requirements implementation for 325 Radiochemical Processing Laboratory training. Prior experience includes instructional technology for the Callaway Nuclear Plant, where she led the instructor certification program and training accreditation efforts, and as an assistant professor of chemistry and physics at Stephens College. She trained with Conger and Elsea, Inc., on causal analysis and has been involved in various operational assessments. She has authored and coauthored several internal publications, as well as peer-reviewed technical publications. Katrina holds a PhD in chemistry from the University of Missouri – Columbia, as well as a BA in chemistry from Missouri Southern State University.

Appendix B. Building a Knowledge Transfer Plan

This section provides information from the literature on key elements of a knowledge transfer plan. Developing a knowledge transfer plan starts with a checklist and the associated answers to the questions in Table 3. The elements in this checklist provide the organizational structure for this section.

Table 3. Checklist of questions

1. What types of knowledge need to be captured and prioritized?
2. How is this knowledge gathered and organized?
3. How is this knowledge shared?
4. How is this knowledge applied and used?
5. How does the organization maintain and evaluate the knowledge to assure relevance?

Knowledge to Be Captured and Prioritized

The first step includes identifying the types of knowledge needed to be successfully captured. Key questions that can help organizations identify the most important information to capture include the following:[2]

- What are the main risks to the organization? The answers to this question will clarify the need to initiate a knowledge transfer plan (e.g., a key member of the team is leaving). Answers to this question also highlight hard deadlines that need to be met.
- What business areas are most impacted by these risks?
- Who are the subject matter experts (SMEs) in these areas of risk?
- What unique tasks do these SMEs carry out that no one else does?
- What knowledge is essential to the jobs that these individuals perform?
- What would happen if a team or individual no longer has access to the knowledge?
- Will this information be required to support or inform future projects, functions, and/or future decisions?

After identifying the knowledge to be captured, consolidate all of the information and order by grading importance, defining availability, and assessing frequency. To quantify, ask the following:

- What information is most needed to keep your business running?
- How many people possess this knowledge?
- How often is this knowledge required?
- Who needs to be involved?

A simple method to streamline the process is to apply a formula that rates knowledge identified above based on three factors: 1) importance, 2) availability, and 3) frequency (see Figure 4). The information is then summed up to determine what information is most important to capture (see Figure 5).

[2] https://www.talentlms.com/blog/knowledge-transfer-plan

IMPORTANCE

Rating	How important is the knowledge to the organization?
3 - Very Important	Transfer cannot be postponed, or primary activities will be impacted. Knowledge is critical to deliver on business objectives.
2 - Important	Transfer cannot be temporarily postponed without significant impact to operations.
1 - Somewhat Important	Transfer could be postponed for some time without impact to operations.

AVAILABILITY

Rating	How available is the knowledge within the organization?
3 - Rare	Knowledge required to perform the activity is rare; very few staff hold it.
2 - Moderately Available	Other staff within the organization have the knowledge required to perform the activity(ies).
1 - Common	Multiple staff across the organization have the knowledge to perform the activity(ies).

FREQUENCY

Rating	How frequent is the knowledge used in the organization?
3 - Frequently	Knowledge is used more than once a week.
2 - Occasionally	Knowledge is used less than once a week and may be used weekly, monthly, quarterly, or annually.
1 - Rarely	Knowledge is used only when a specific situation arises.

Figure 4. Formula for prioritizing the knowledge to be captured[3]

PRIORITY = IMPORTANCE + AVAILABILITY + FREQUENCY

PRIORITY	SCORE	DESCRIPTION
High	7 to 9	The knowledge is essential to achieving the organization's objectives; not widely available and used frequently. Actions should be taken immediately to capture or transfer knowledge.
Medium	4 to 6	The knowledge is less important to achieving the organization's objectives; may be more commonly available within the organization or may not be used as frequently. An action plan should be established to capture or transfer knowledge.
Low	3	The knowledge is not essential to achieving the organization's objectives; is commonly available and may be used infrequently or cyclical. Although it's low in priority, determine a plan for transferring knowledge. This may be the easiest to transfer.

Figure 5. Summarizing knowledge to be captured

[3] Methodology by "Knowledge Transfer Guide," British Columbia Public Service (https://www2.gov.bc.ca/assets/gov/ careers/managers-supervisors/knowledge-transfer/knowledge_transfer_manager_guide.pdf)

Knowledge to Be Gathered and Organized

Once the most important information has been identified and prioritized, the knowledge will need to be gathered. The first step is to develop a list of all the SMEs identified and use the following guide to capture their knowledge.

It's important to keep in mind that the process used should not revert to lengthy, data-dump sessions. Candidate questions for SMEs include the following:

- Describe critical tasks and their level of importance.
- Describe why the tasks are important.
- Describe when and how often each task or activity is carried out.
- Describe if there are any dependencies and who is impacted.
- Describe the resources required to carry out the tasks.
- Describe what technical information is needed (e.g., access rights, etc.).
- Describe the limitations of the current process.
- Describe how the current process could be improved.
- Describe risks to the current process or risks that could prevent delivery and/or completion of work.
- Describe any quirks, bugs, workarounds, or shortcuts that form part of the process.

Table 4. Ways in which to gather information

For **explicit knowledge**, provide the best methods for capturing the information:

- guided experience
- documentation
- simulation
- wikis
- audio
- video
- transcripts
- graphics and charts.

Some ways to capture **implicit knowledge** include the following:

- mentorship
- paired work
- guided experience
- communities
- work shadowing
- informational interviews
- coaching
- job aids.

After getting these answers, classify each piece of information, whether it's

- **Explicit:** Knowledge that's easy to share and document.
- **Implicit or Tacit:** The application of explicit knowledge (i.e., transferable skills) and knowledge acquired through experiences, observations, and insights.
- **Transient:** Knowledge that's made, used for a while, and then becomes obsolete.

The IO assessment team observed that PNNL organizations employ various techniques to capture and share information (see Figure 6). To assure knowledge is readily accessible and preserved, organizations often employ techniques to codify and store knowledge. These may include creating databases, knowledge repositories, or utilizing digital tools for efficient retrieval and dissemination. An organized knowledge management system facilitates efficient access and use, prevents knowledge loss, and enables continuous improvement.

Figure 6. Ways PNNL captures and shares knowledge

Sharing Knowledge

Sharing knowledge is about getting the correct information to the right people, at the right time, and in an appropriate format for its use. While there are a number of methods available, the guiding principle is to make it easy for staff to share what they know in a way that makes sense to the receiver. In order to share knowledge, it is important to consider the following:

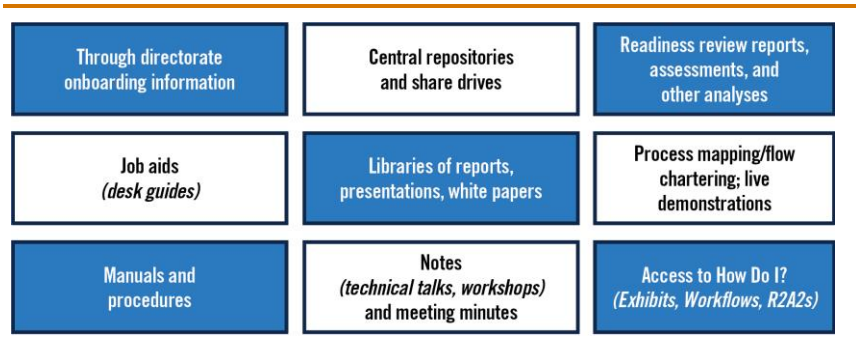


Figure 7. Organizing knowledge includes many methods

- Who needs the knowledge to deliver value to the organization?
- Who are the targeted users for the key knowledge that has been identified?
- Is it prudent for business succession management or other reasons to transfer this knowledge to multiple individuals?
- How much time and what resources are needed and available?
- How many staff are involved (e.g., instructor-led training is a good way of sharing knowledge that is valuable to a larger group or team, whereas on-the-job training is better if sharing knowledge is one-on-one)?
- What are the preferred channels of communication of the people involved?
- What security and privacy levels apply to the information being shared? This will determine how widespread the transfer of knowledge can be and the methods used.

Solutions ultimately need to be tailored to the existing set of conditions. Organizations have developed strategies to respond to specific needs and employees' varying learning preferences. The tools for transferring explicit knowledge include expert blogs, how-to videos, wikis, webinars, podcasts, infographics and diagrams, standard operating procedures, and frequently asked questions on intranet sites.

Similarly, the tools for transferring implicit know-how include mentoring and coaching arrangements, work shadowing, simulations and games, coaching and development, CoPs, and apprenticeships. It is important to curate the information so that it is searchable and easy to access.

Applying Knowledge

Applying knowledge is the delivery or sharing of critical information or best practices across the organization, thereby enabling individuals and work teams to learn from one another and improve their processes and work outcomes. Applying knowledge is *the demonstration* of "knowledge transfer."

Applying different methods, such as formal training, CoPs, and mentoring, offers unique avenues for sharing and utilizing knowledge within organizations. Each method has its own benefits and challenges that need to be considered based on the organization's specific context and objectives. Examples include the following:

- Formal training programs and workshops are traditional methods employed to transfer knowledge within organizations. These structured sessions provide a platform for SMEs to share their expertise with staff. By delivering information through presentations, discussions, and interactive activities, these methods foster learning and skill development. Additionally, formal training allows for the standardization of knowledge across the organization, ensuring consistency and alignment. The challenges associated with training include the high cost associated with designing and conducting training programs, limited scope for practical application and hands-on experience, and retention of knowledge acquired through one-time training sessions.
- CoPs are informal groups consisting of individuals sharing a common interest or expertise. Within these communities, knowledge transfer occurs through collaboration, shared experiences, and problem-solving discussions. CoPs promote peer learning and provide a platform for exchanging implicit knowledge, which is often difficult to articulate formally. Challenges include lack of structure and accountability in CoPs, difficulty in measuring the impact of knowledge transfer within these communities, and limited scalability, as CoPs may be specific to certain domains.
- Mentoring and coaching programs establish a one-on-one relationship between a more experienced individual (mentor) and a less-experienced individual (mentee). Knowledge transfer occurs through guidance, feedback, and practical advice provided by the mentor. This method focuses on personal development and fosters individual growth by transferring specific skills and knowledge. Challenges include availability of suitable mentors with relevant expertise and time commitment, potential dependency on mentors for learning, limiting self-sufficiency, and challenges in maintaining the continuity of mentorship programs.

By employing a combination of these methods, organizations can enhance their learning culture and improve employee capabilities.

Maintaining and Evaluating Knowledge

To assure the longevity and accessibility of knowledge, organizations should employ systematic methods for documenting and standardizing information. Evaluating the effectiveness of knowledge transfer practices is essential to assure that knowledge is shared efficiently and accurately. Below are several methods that can be used for evaluating knowledge transfer in an organization:

- *Qualitative Assessments*. Qualitative assessments provide valuable insights into the subjective experiences and perspectives of individuals involved in the knowledge transfer process. Assessments involve gathering feedback from employees or participants involved in the knowledge transfer process. Surveys, interviews, and focus groups can be used to collect qualitative data on the perceived effectiveness of the knowledge transfer practices, barriers encountered, and suggestions for improvement.
- *Quantitative Assessments.* By analyzing quantitative data, organizations can track progress, identify trends, and compare outcomes over time. Quantitative assessment involves measuring specific metrics related to knowledge transfer. Key performance indicators (KPIs), such as the time taken to transfer knowledge, the

accuracy of information shared, and the retention of knowledge by recipients, can be quantitatively measured to assess the impact of knowledge transfer practices.

- *Observation.* Observations can be used as an evaluation method to directly observe knowledge transfer practices in action. Observational data provides a real-time and firsthand perspective on how knowledge is being transferred and received, offering valuable insights into the effectiveness of knowledge transfer practices. Trained observers can monitor knowledge-sharing activities, interactions between individuals, and the use of tools and technologies to facilitate knowledge transfer.
- *Knowledge Transfer Assessments*. Through assessments, organizations can identify gaps, redundancies, and areas for improvement in their knowledge transfer processes. Knowledge transfer assessments can be conducted to evaluate the overall effectiveness of knowledge transfer practices within an organization. These involve reviewing documented procedures, policies, and training materials related to knowledge transfer, as well as analyzing data on knowledge-sharing activities and outcomes.

By leveraging these evaluation methods, organizations can identify strengths and weaknesses in their knowledge transfer processes and implement targeted improvements to enhance knowledge sharing and collaboration.

Appendix C. Onboarding, Cross-Boarding, and Offboarding

Onboarding

The onboarding process for new staff members consists of a new hire orientation and further local onboarding conducted by the staff member's organization. New hire orientation is conducted by HR via a one-day virtual session with a focus on Laboratory-level topics. This onboarding is via Learning and Development @ PNNL and consists of 30-, 60-, and 90-day learning journeys about the Laboratory.[1]

After this initial new hire orientation, the team leader (or immediate manager) continues with local onboarding activities, which are important for the new hire's successful transition into their role. These activities include accessing critical information needed to be successful, assigning experienced mentors or peer partners (and coaches for executives), and developing an onboarding schedule. Implementing these practices can help accelerate the new hire's productivity.

The effectiveness of the local onboarding process may vary significantly. If new hires feel disconnected from the organization or are uncertain about their roles, they may struggle to meet productivity expectations.

Cross-Boarding

Cross-boarding refers to the internal movement of staff within the organization instead of hiring new employees externally. This practice offers several advantages, including faster productivity, as new hires can learn quickly from experienced colleagues. It also reduces the risks associated with hiring external candidates whose skills may not be fully known until later on. Moreover, cross-boarding promotes employee engagement by providing opportunities for skill development, career growth, and recognition. Additionally, it enhances long-term retention, as employees are more likely to stay when they see growth opportunities within the organization.

Although formalized cross-boarding expectations are not universally established, some organizations offer training and peer support to new staff members. Succession candidates are given chances to learn potential new roles before applying for them, working alongside incumbents and gaining a better understanding of the responsibilities. This approach has been found to be positive and successful.

Offboarding

Offboarding is the process of managing staff departures from an organization. Its purpose is to facilitate the transfer of knowledge and responsibilities from departing employees to new ones, assuring a smooth transition. This process also aims to maximize the productivity of the successor. To achieve effective offboarding, it is recommended to conduct knowledge transfer sessions where departing employees document important processes, projects, and systems for the new hires to reference during onboarding. Open and honest communication throughout the offboarding process is essential, providing successor staff with advanced notice, guidance regarding job requirements, and expectations.

Succession planning typically involves creating a list of potential candidates to replace the outgoing employee. However, it is unclear whether there is consistent follow-up to assess if these candidates obtain the necessary experience and expertise.

[1] See https://pnnl.sharepoint.com/sites/LearningPNNL/SitePages/Onboarding.aspx for more information.

Appendix D. Reference Library

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