Pacific Northwest
NATIONAL LABORATORY

Implications of the Science of Learning for Qualification of Personnel for Ultrasonic Examination

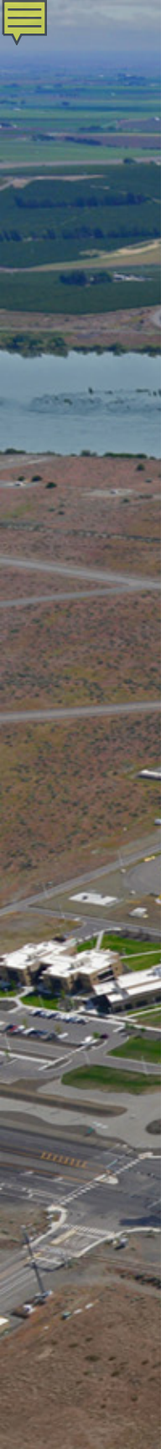
Thomas F. Sanquist, Ph.D., Research Scientist
NRC/Industry NDE TIE
January 14, 2020

Work sponsored by US NRC Office of Research

Carol A. Nove, COR

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy



Preview of Recommendations

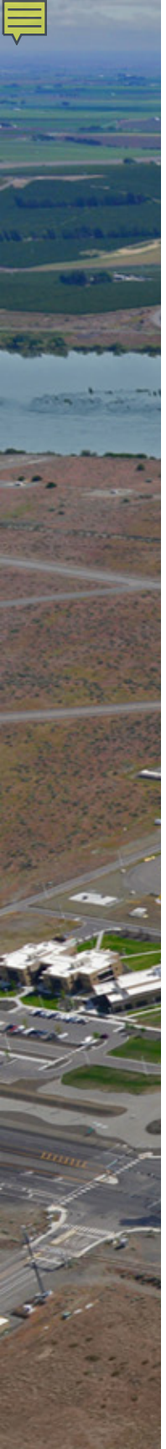
1 – Increase lab practice

2 – Objectively define experience time

3 – Provide sufficient field experience

4 – Use distributed practice learning principle for lab practice

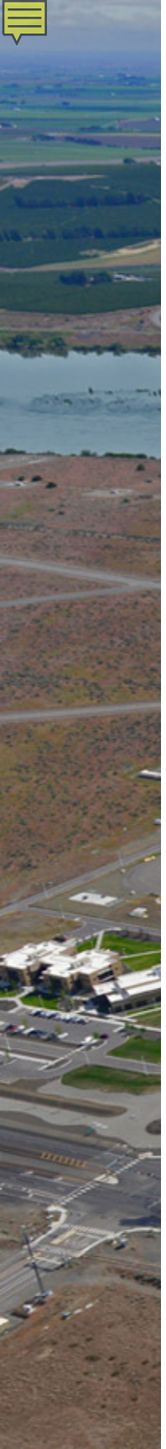
5 – Provide structured learning opportunities and feedback for lab practice and field experience



Pacific Northwest NATIONAL LABORATORY

Introduction

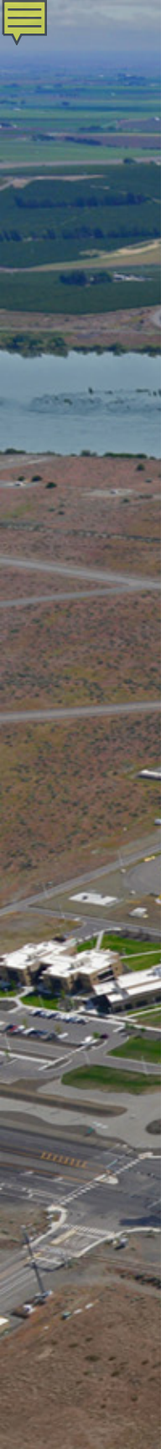
- Changes in ASME Code Section XI, Appendix VII (2011) reduced experience hours required for Level II certification from 800 to 400, permitting 320 of those hours to be laboratory training. (Table VII-4110-1, Required Experience for Initial Certification for Ultrasonic Examination (Hours)). Currently, 10CFR 50.55a prohibits the use of reduced experience hours.
- NRC initiated research to investigate the technical basis for training requirements through a scientific literature review of studies concerning human learning, retention, training, and application of knowledge.
- Product – integrative literature review and recommendations concerning technical basis for NDE training hours and types.
- Issues:
  - Reduced size of workforce
  - Lack of opportunities to detect flaws in operational plants
  - Fewer opportunities for training during inservice inspections than earlier periods
- Outcome: there is latitude to reduce experience hours with increase in lab practice
  - We address five recommendations for how to implement this, based on fundamental learning principles



Pacific Northwest NATIONAL LABORATORY

Background

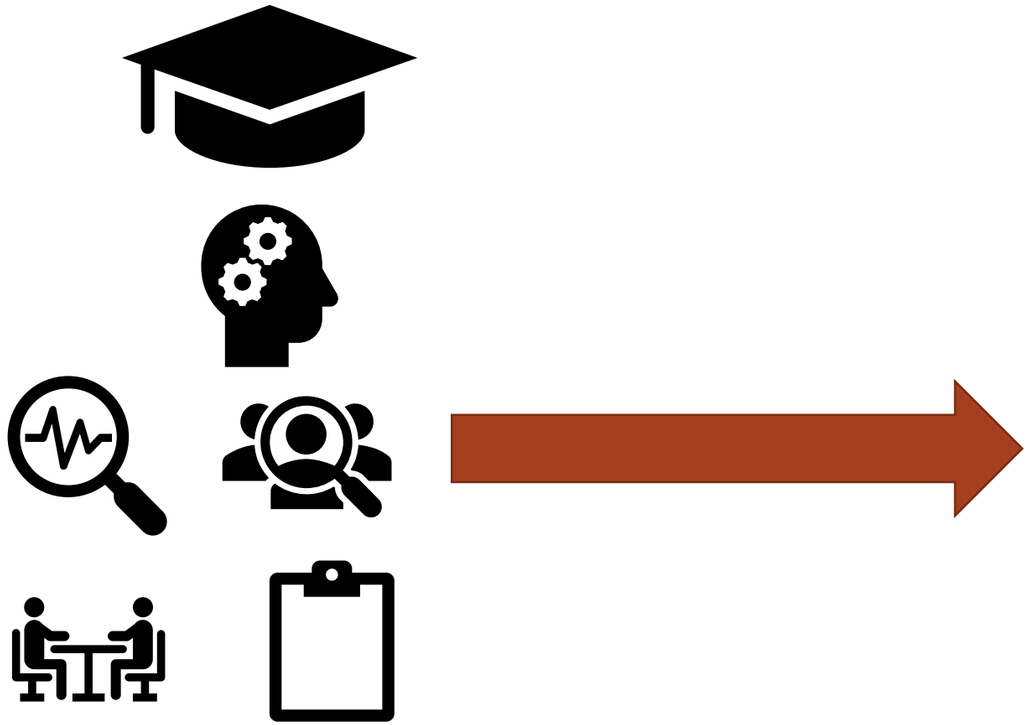
- Supervised experience time requirements common in many skill-based jobs, e.g.,
  - Flying hours for pilots
  - Clinical practice for doctors
- Goal of training and field experience
  - Develop applicable knowledge and skill
  - Perform job task at a level of proficiency to work unsupervised (“journeyman” level)
  - “Proficiency” currently based on passing a performance test (Appendix VIII) after required amount of field experience (Appendix VII)
  - Performance testing not intended as method to assess systematic training and experience needed for personnel to acquire skills to successfully perform NDE (Doctor, 2013).
- Changes in experience time requirements generally involve considerable debate



Fundamental Principles

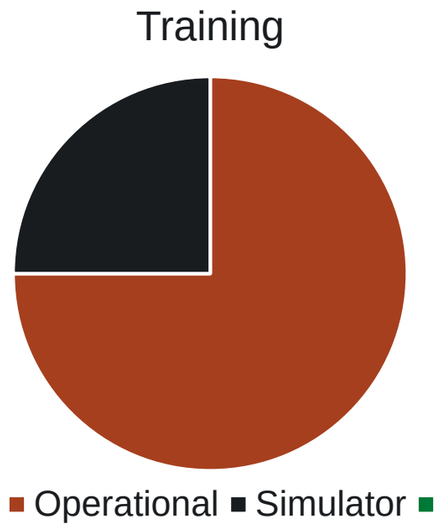
- Total Time: more learning time results in better performance
- Incidental Learning: Learning can occur in the absence of overt behavioral change
- Distributed Practice: Learning time that is distributed across intervals rather than massed together yields better retention
- Knowledge Testing: Testing can enhance retention, independent of further study
- Feedback: Feedback that informs the learner as to the correct answer on a test, presented after the test is completed, enhances retention and can be used to correct errors.
- Transfer of Training: Practice on parts of tasks that are similar or identical to elements of the task being learned results in positive transfer of learning, i.e., the new task is performed better than if practice on related tasks had not occurred.
- On-the-Job Training (OJT): OJT is a systematic process based on analysis of the task to be performed, development of instructional situations from the operational environment, employment of instructional techniques such as demonstration and observation as warranted, and evaluation of performance based on increasing competence in operational tasks.
- Proficiency and Expert Performance: Proficiency and eventual expertise develops over a long period of time, requiring deliberate practice of component tasks at increasing levels of difficulty to challenge the current skill level.
- Perceptual Learning: Experience can change how people perceive visual patterns, increasing the ability to extract information from the environment.
- Active Learning: Learning material that is processed more “deeply,” i.e., with elaboration of content though meaningful engagement – as distinct from passive activity such as rote repetition or verbatim note-taking – will be retained better.

Translational Science – from research to application. What should we do about practice and field experience?



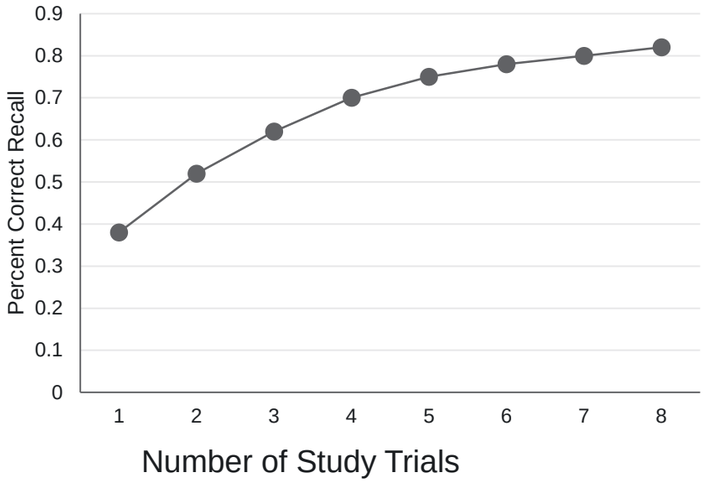
Recommendation 1

- Increase opportunities to practice detection and flaw characterization by use of laboratory practice exercises that simulate the types of examinations that would be done in the field.
  - Provide sufficient time and feedback to ensure mastery of the relevant techniques
- **Applicable Learning Principles**: Total Time, Transfer of Training, Perceptual Learning, Feedback



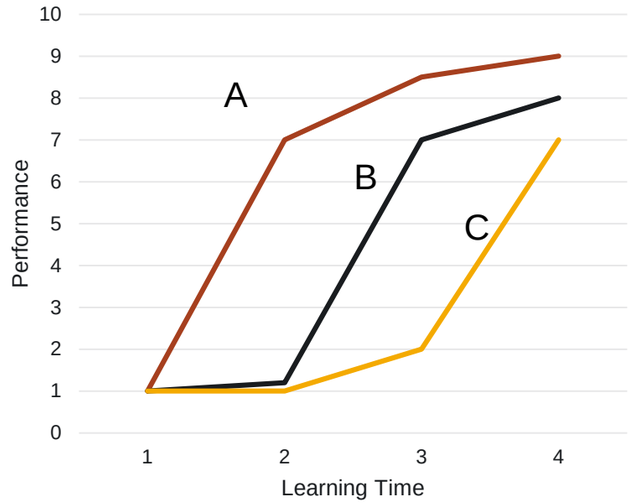
Recommendation 1, Considerations

- Consistent with current Appendix VII allowing increased hours of lab practice on UT techniques and components likely to be encountered in field conditions.
- Time provided for exercises should be based on objective criteria for demonstrating mastery, such as supervisor ratings, performance scores in practice tests, and overall likelihood of passing PDI tests.
- Not a substitute for field experience; instead it is *augmentation*
- Implement provisional Level II certifications to ensure effectiveness



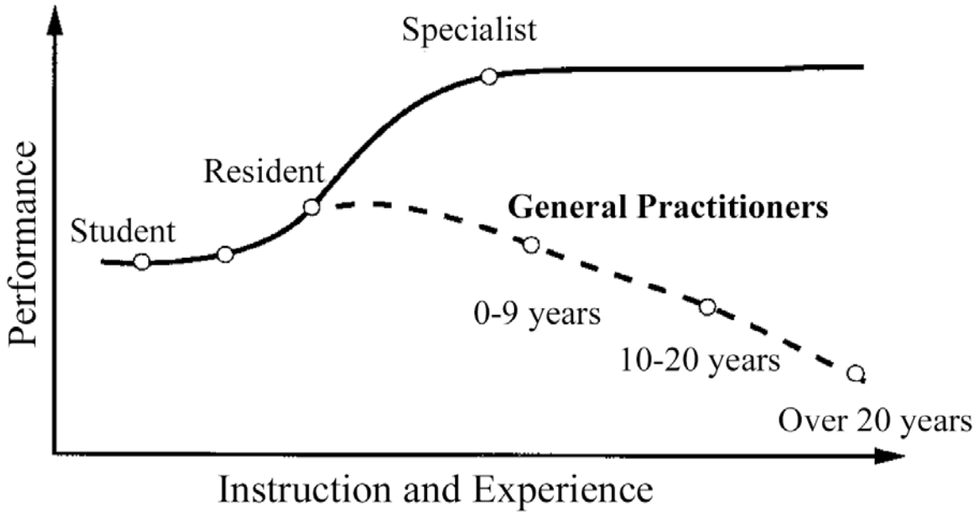
Recommendation 2

- Define the relationship between hours of experience and frequency of UT task performance.
  - Current proposals for lab practice and field experience hours use a table of frequency X hours per task (lab practice) or total time in hours (field experience) to yield total experience time.
  - A more detailed basis for what tasks and subtasks contribute to the time estimates will provide supervisors and regulators with a better understanding of how to implement and evaluate Code modification proposals.
- **Applicable Learning Principles**: Total Time, OJT, Distributed Practice



Recommendation 2, Considerations

- An issue with basing qualifications on experience time is the specific definition of “time.”
- Time and frequency of task are related, but unclear whether the number of times the task is performed, or the duration of the task is the key variable in developing proficiency.
- **On-the-Job Training (OJT):** Specific criteria for what is to be observed and then demonstrated by the trainee. Full demonstrations of tasks, as well as parts of tasks by instructors, should form the basis for student demonstration of proficiency.
- Simple “experience accrual” is not sufficient.
- Amount of time and allocation can be better defined through systematic estimates by subject matter experts.



Recommendation 3

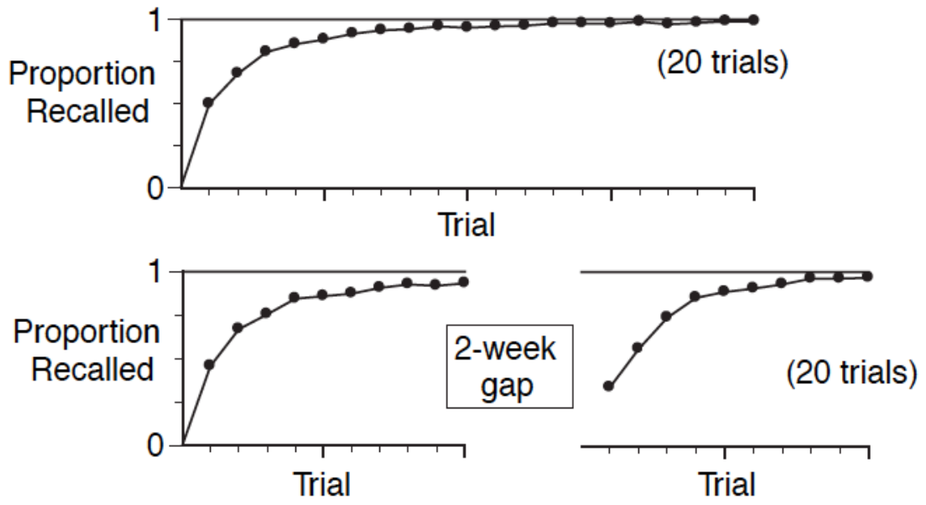
- Provide *sufficient* field experience in nuclear plant inservice inspections to develop proficiency of the knowledge and skills necessary to conduct examinations in realistic operational settings.
  - Time in field experience should complement laboratory practice such that total experience time is equivalent with Code requirements currently accepted by the NRC (800 hours)
  - Field experience should be based on a structured approach to on-the-job training to ensure that all techniques addressed in laboratory practice are observed, demonstrated in the field under supervision, and feedback provided to the trainee concerning their performance.
- **Applicable Learning Principles**: Total Time, Incidental Learning, Distributed Practice, On-the-job Training, Proficiency and Expertise, Active Learning.

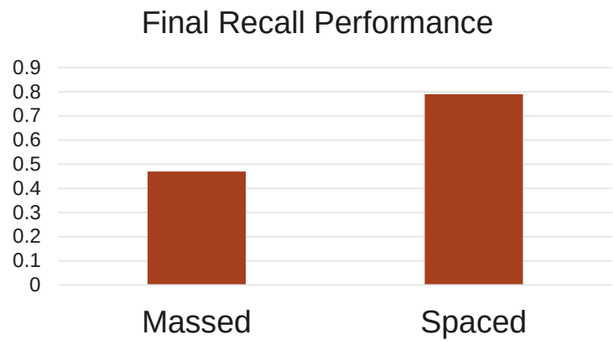
Recommendation 3, Considerations

- Could reduce field experience hours substantially, recognizing the potential contribution of laboratory practice.
- Many aspects required to develop proficiency for skill application in operational environments besides detection and characterization of flaws
  - ✓ learning how to navigate through containment/inspection areas,
  - ✓ executing procedures in complex circumstances,
  - ✓ observing multiple geometries,
  - ✓ addressing issues of coverage limitations, and
  - ✓ generally learning flexibility to adapt the examination process while maintaining compliance with the qualified procedure,
  - ✓ experience in diverse operational cultures and expectations
- Code reduction to 80 hours of field experience is unacceptably low
- Proficiency and eventual expertise has been shown to require as much as 10,000 hours to develop.
- Potential “provisional” certification

Recommendation 4

- Develop a schedule for laboratory practice that distributes the practice sessions for various techniques over intervals separated in time, e.g., a week or a month, based on what is feasible for trainees, oversight supervisors and lab facilities. Incorporate testing of previously practiced material.
- **Applicable Learning Principles**: Distributed practice

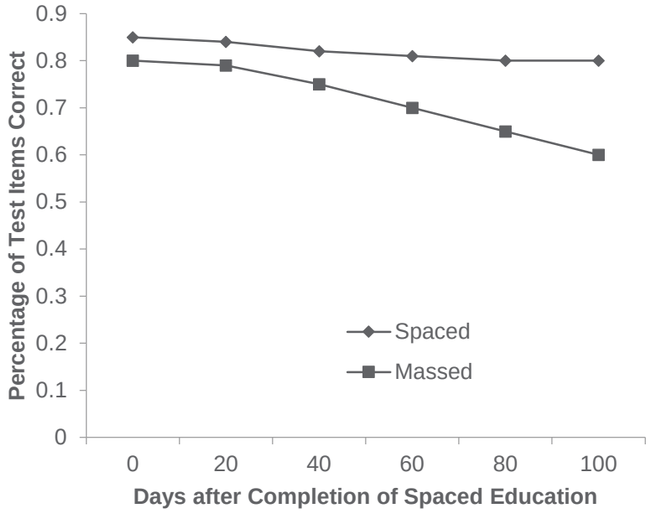




Recommendation 4, Considerations

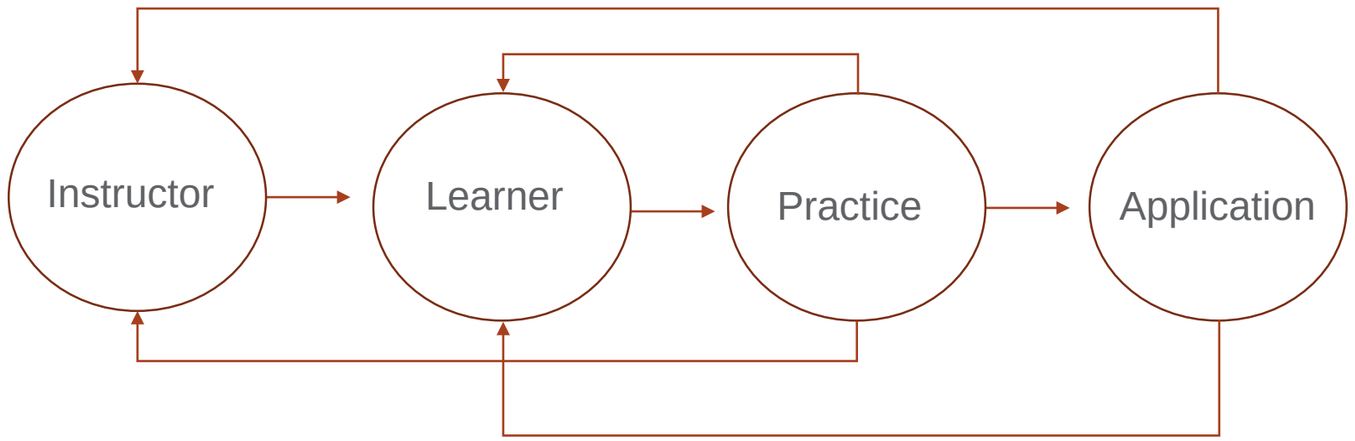
- Spacing of lab exercises over time so that more durable learning takes place.
- Several hours of practice on alternate days
- Current approaches to prepare for performance testing involves massed practice on samples in the time period immediately preceding the test
- Feasibility – practice sample availability, location, oversight

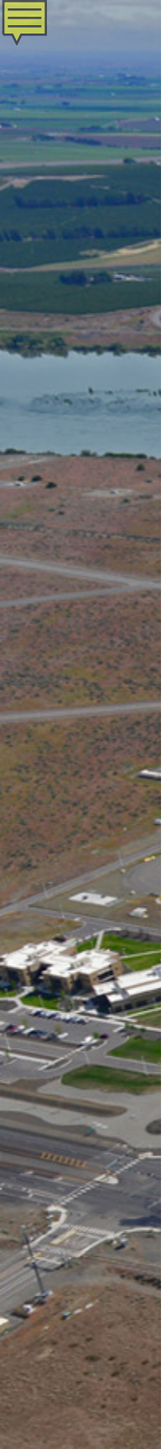
Medical Students: Better long-term retention with spaced practice



Recommendation 5

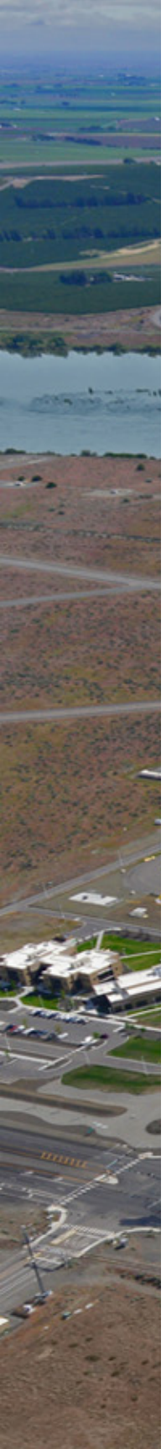
- Develop a protocol for laboratory practice that incorporates feedback to the trainee concerning their performance addressing (1) performance accuracy, (2) process of examination, (3) how the trainee can monitor their own performance, and (4) increasingly difficult problems to challenge the current trainee skill level.
- **Applicable Learning Principles**: Feedback, Proficiency and Expertise





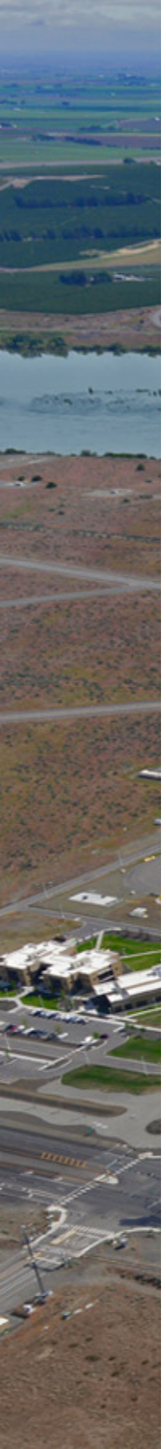
Recommendation 5, Considerations

- Considerations
  - Laboratory practice for UT procedures permits the opportunity to provide more feedback concerning performance
  - Feedback not only about performance accuracy – whether the flaw was correctly detected and sized – but also about how the trainee performed the task, and how they can monitor their own performance to ensure proper task completion
  - More intensive for early trainees who will require considerable oversight, while in the latter periods of lab practice, less scrutiny would be necessary
  - Feedback provided by Level III supervisors might address how such examination procedures would be performed in the field, and practical considerations that are typically encountered in operational settings
  - Graduated levels of difficulty for the practice specimens will permit the trainer to challenge the current skill level of the trainee, so that current knowledge is pushed and extended



Summary

- Time requirements exist to ensure that trainees have sufficient opportunity to experience and perform their job tasks at an acceptable level of proficiency so that they can work unsupervised – the “journeyman” level of performance
- Difficulty with NDE Level II experience is defining exactly what “proficiency” means
  - Currently, passing the performance demonstration test after the required amount of field experience is one way to demonstrate proficiency.
- Changing one of the core aspects of proficiency development – e.g., field experience hours, should be carefully evaluated and addressed conservatively
- Increased laboratory practice is commensurate with guidance from the literature



Summary, continued

- Reducing field experience, however, is a more challenging issue
- Reducing field experience to 80 hours provides only a token amount of time
- More appropriate would be to ensure that field experience actually does provide adequate time to observe and execute UT examinations under supervision, and that this is done frequently enough to develop operational proficiency
- There is latitude to reduce the overall number of experience hours with a corresponding increase in lab practice
  - Proposals should be evidence-based and include a rationale for accumulating adequate experience to develop proficient examiners

Pacific Northwest
NATIONAL LABORATORY

Thank you