Reducing Interpretive Errors on Common Imaging Studies through Deliberate Practice and Mastery Learning

I. Specific educational aims: The goal of this project is to integrate and validate principles of deliberate practice and "Mastery" learning into Radiology image interpretation. We will utilize and advance a teaching file software platform we developed called STELLA (STanford Electronic Learning Library & Applications) which is a flexible tool for creating searchable metadata and displaying radiological images from Stanford's Picture Archive and Communication System (PACS). Specifically, our team will build into STELLA a rigorous framework to help learners develop mastery of core image interpretation tasks critical to patient care and safety. This project addresses a significant weakness in Radiology education, which traditionally relies on a variable apprenticeship model where "competence" is highly subjective and may only reflect completion of a rotation.

II. Project rationale: Traditional teaching on image interpretation relies primarily on a master-apprentice model. A learner, such as a medical student, resident or fellow, learns the skills from more experienced individuals. As radiology has expanded with new modalities and subspecialization, it is very difficult to achieve expertise in all ~10 subspecialty areas. Moreover, the time available for high quality teaching has declined; faculty are stressed to get through increasing clinical workloads. Standardized testing is part of radiology training and assessment but does not accurately reflect real-world practice. The end result is that significant gaps in trainee competency are often not recognized until they begin independent overnight call, when mistakes in their preliminary interpretations can lead to negative clinical outcomes.

Mastery learning through deliberate practice was originally developed in the context of procedural skills and has been shown to be superior to traditional medical teaching methods with regards to procedural skills[1]. Deliberate practice is based on the concept that one needs to focus on weaker skills rather than those already mastered. Initial pilot work by others suggests an impactful role for mastery learning in Diagnostic Radiology[2]. A pilot study demonstrated the feasibility of creating competency-based teaching methods to assess residents in Pediatric Radiology[3]. Work in our own department has begun to employ these principles for focused tasks in orthopedic radiology, including detection of hip fractures, knee joint effusions, and assessment of orthopedic hardware.

The current project will help to advance radiology education through creation of Mastery modules within the Stella Teaching Application, which allows for customized learning sets and individualized trainee viewing and scoring that can be quantified and utilized for concrete, specific feedback.

Our hypothesis is that trainees educated with mastery learning modules can achieve a level of performance similar to subject experts. We further hypothesize that there will be less variation in performance across trainees when provided with mastery training.

III. Approach: Our initial modules are a subset of the ACR Critical Results Group and includes very common imaging findings that require a high level of expertise to avoid negative patient outcomes: (1) pneumothorax, (2) misplaced support devices on adult chest x-ray, and (3) pneumoperitoneum.

Pneumothorax and misplaced support line modules are already in development within the Stella Teaching Application, and pneumoperitoneum cases are being curated.

All imaging examinations included will be evaluated by at least two attending radiologists to establish the reference standard. For each case we use Stella to record clinical history, text and graphical annotation of findings and diagnosis, as well as ratings of perceptual difficulty. We are targeting modules containing 15 pre- and post-test cases and up to 30 independent training cases of varying perceptual difficulty.

Modules will be assigned to radiology residents in their first or second rotation on thoracic, cardiovascular, and gastrointestinal imaging. With 13 residents per class, 2 rotations, and 3 modules, we

expect up to 78 resident testing instances to employ our approach. In Stella, we will create individual pre- and post-testing worklists for each module and resident, in which the answers are hidden. Study phases are as follows:

Phase 1 – Pre-Test: Each resident will review and be required to add a graphical annotation (arrow, circle) to localize findings and to create a brief report on 15 cases in each of the three modules. Confidence in the findings will be recorded. This will establish the baseline level of performance.

Phase 2 – Mastery Training: Residents will undertake self-paced review of instructional materials including short video tutorials created by faculty experts and view up to 30 additional training cases that are independent of the Pre-Test cases. The total number of training cases may be based on their baseline performance, with more cases assigned to those that perform lower at baseline.

Phase 3 – Post-Test: Residents will be required to review and annotate an additional set of 15 cases that are independent of the Pre-Test and Mastery Training Cases. Confidence will again be recorded.

IV. Timeline and plan for implementation

Oct – Dec 2023: Establish testing and training datasets and create faculty annotations for each module. Submit IRB application.

Jan – Feb 2024: Complete Phase 1 Pre-Testing. Score resident results against faculty reference standard to established initial performance levels compared with the reference standard.

March – May 2024: Complete Phase 2. All trainees will undertake self-paced, Mastery Training with up to 30 cases.

June– July 2024: Complete Phase 3 Post-Test. Residents scoring below the Mastery level will be assigned additional training cases and materials and re-tested, until each of them scores above the Mastery level.

V. Anticipated work product: The TMA grant will enable creation of a framework for deliberate practice and mastery learning in Diagnostic Radiology that can be extended to other critical tasks such as intracranial hemorrhage, ectopic pregnancy, ruptured abdominal aortic aneurysm, unstable spine fractures, ovarian torsion, and many other diagnostic entities. The methods can also be extended into concepts around procedural tasks and Interventional Radiology, as well as applied to other specialties learning to interpret critical findings on imaging exams.

VI. Evaluation plan: The primary result will be to measure residents' performance on pre- and post-tests and to determine the proportion of residents that achieve mastery with initial training and those that need further training. Residents will also complete pre and post surveys assessing learner satisfaction with the Stella supported mastery training and comfort level with the cases before and after completing the mastery training. Statistical analysis will be conducted with support from the Department of Radiology. Secondarily, we will establish how much additional training is needed to help lower performers eventually achieve mastery and an acceptable level of diagnostic confidence.

VII. Dissemination of results: The results of this project will be submitted for presentation at Stanford Education Day as well as annual meetings such as Radiological Society of North America (RSNA), Academy of University Radiologists (AUR), and others. The Stella Software Application is Open Source and entirely coded in the Stanford School of Medicine over the past ~5 years. Work such as this demonstrating its educational value and Deliberate Practice can be translated to other departments such as Emergency and Critical Care Medicine.

References

1. McGaghie, William C. PhD; Issenberg, S. Barry MD; Cohen, Elaine R.; Barsuk, Jeffrey H. MD; Wayne, Diane B. MD. Does Simulation-Based Medical Education With Deliberate Practice Yield Better Results Than Traditional Clinical Education? A Meta-Analytic Comparative Review of the Evidence. *Academic Medicine* 86(6):p 706-711, June 2011. | *DOI:* 10.1097/ACM.0b013e318217e119

2. Shu L, Bahri F, Mostaghni N, Yu G, Javan R. The Time Has Come: a Paradigm Shift in Diagnostic Radiology Education via Simulation Traning. J Digit Imaging. 2021 Feb;34(1):212-227. doi: 10.1007/s10278-020-00405-2. Epub 2020 Dec 2.

3. Castro D, Yang J, Greer ML, Kwan B, Sauerbrei E, Hopman W, Soboleski D. Competency Based Medical Education- Towards the Development of a Standardized Pediatric Radiology Testing Module. Acad Radiol. 2020 Nov;27(11):1622-1632. doi: 10.1016/j.acra.2019.12.005. Epub 2020 Feb 3.