



Predicting Remediation Need in Pharmacy Calculations Courses

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Objective: Establish measures that predict academic progression and need for metacognitive remediation in Pharm.D. students enrolled in calculations courses at the University of Saint Joseph. Hypotheses to be tested: 1) students with strong math skills would constantly outperform less numerate students, 2) completion of calculations courses would close the performance gap across the class.

Methods: Students enrolled in two 5-week long Pharmaceutics and Calculations courses were followed. Mathematical ability and critical thinking were assessed in tests using multiple choice and handwritten responses to longitudinal math problem sets with increasing complexity, before, during and at the end of the courses. Tests were conducted using both open and closed book paradigms. Student scores and rank in class were determined for each of 9 time points.

Teaching Materials: The 10-week calculations curriculum covered: pharmaceutical measurement, ratio strength, parts per million, alligation, dosing, milliequivalents, millimoles, milliosmoles, isotonic and buffer solutions, ionization of water, reducing and enlarging formulae, weak acids and bases, buffer systems, calculations from standard formulae and equations, enteral and parenteral nutrition and admixtures and calculation of strengths of products as percentages. Didactic material was paired with critical thinking exercises, use of extensive practice question banks, NAPLEX-like questions and deconstructed structured questions.

Exams: Formative exams were administered using Examsoft and handwritten paper responses, under closed-book conditions. Simplified elements of the curriculum were included in the 10-question quiz administered at the start of year orientation.

Remediation: Students were able to retake the exam under open-book conditions. They were eligible for 50% credit for failed questions if they could show the correct calculation steps when provided with the correct numeric answer.

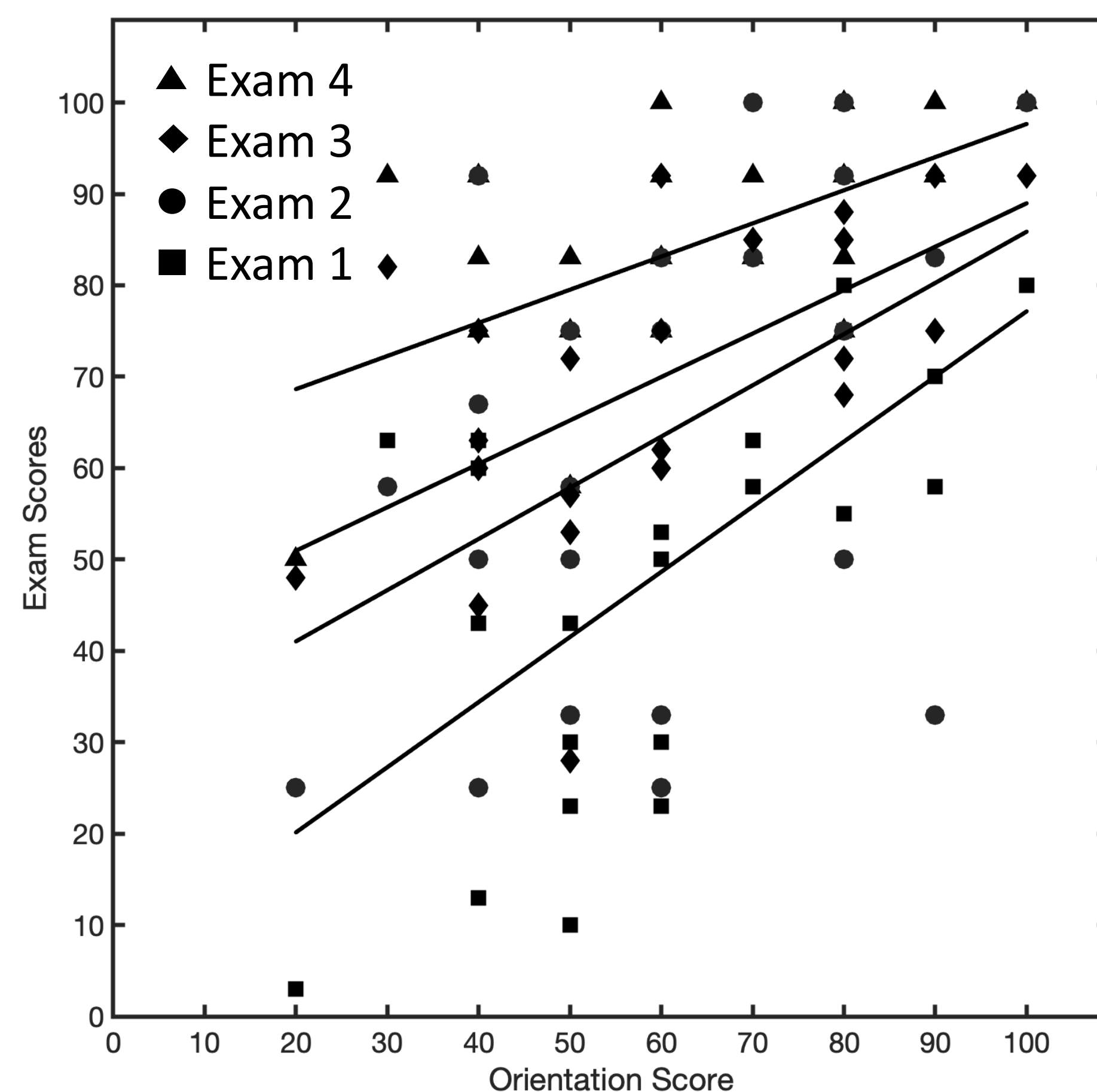


Figure 1: Relationship between orientation score and 4 formative course exam scores. There was a strong positive correlation ($r=0.7$) between the 10-question orientation quiz and the performance throughout the course.

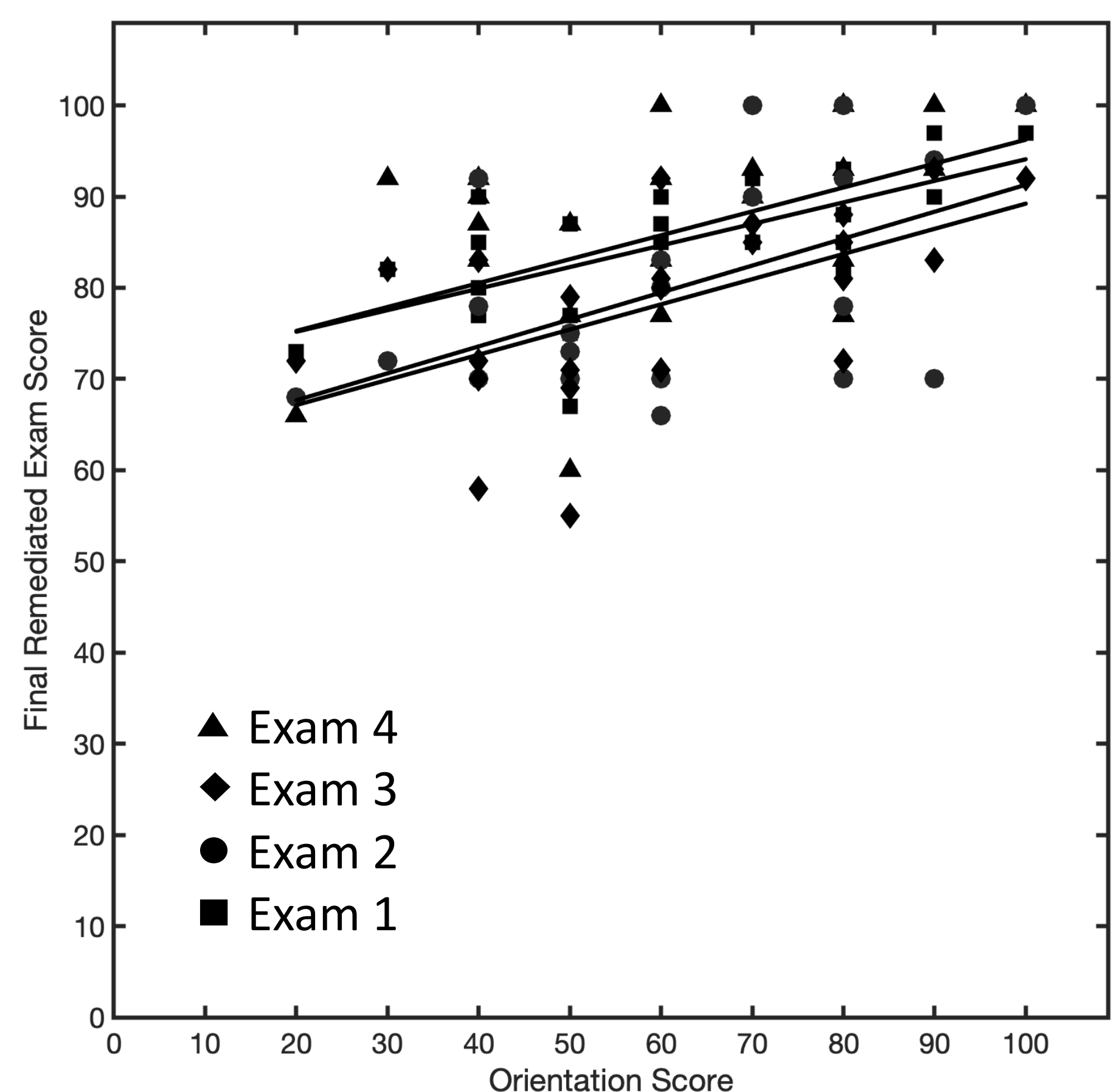


Figure 3: Relationship between orientation score and remediated final score. Error review & reflection and guided solution exercises resulted in large gains in performance.

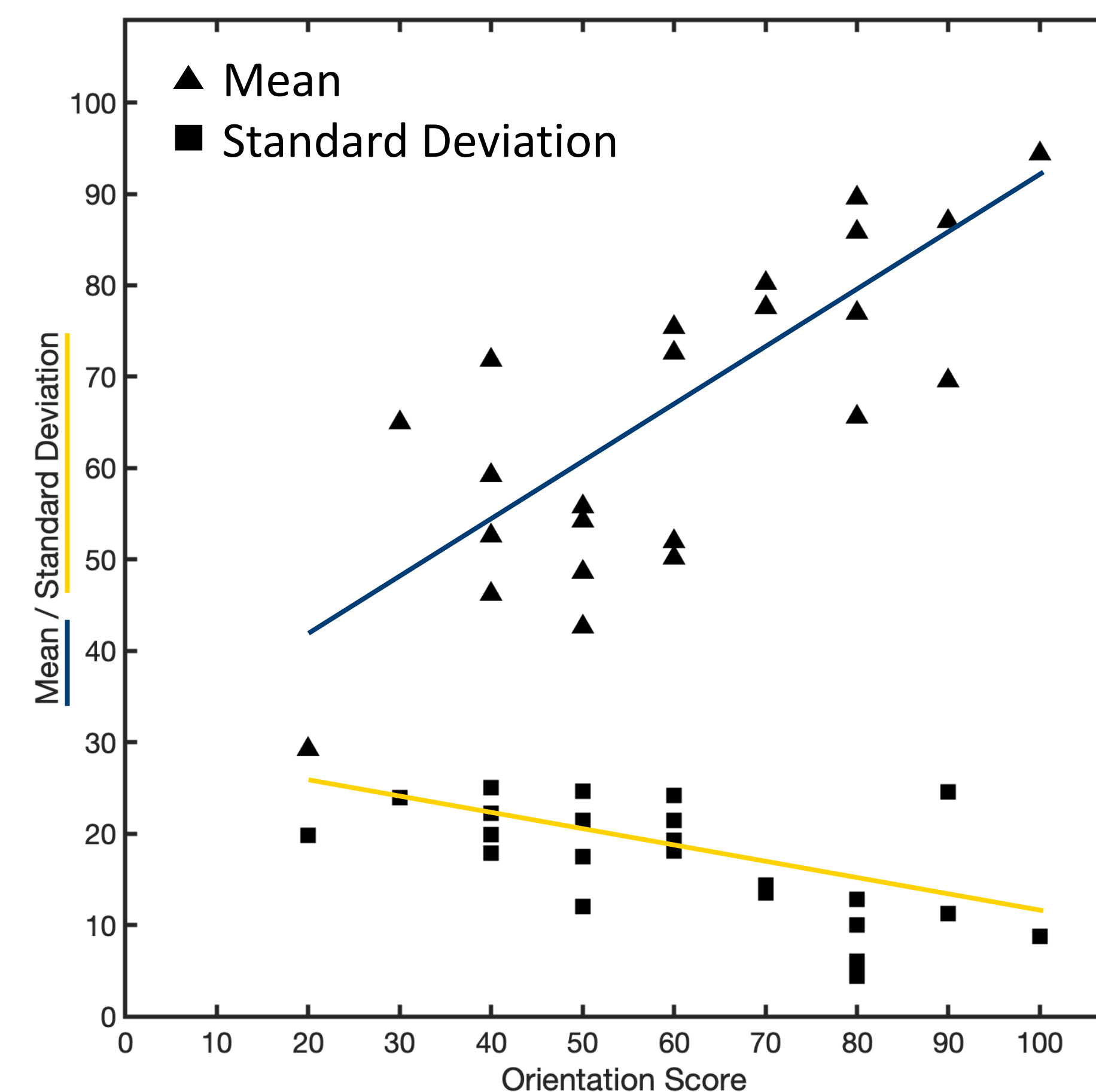


Figure 2: Relationship between orientation scores and overall performance and score variance. High-performing students recovered few points from remediation. The opposite was true for students with low scores.

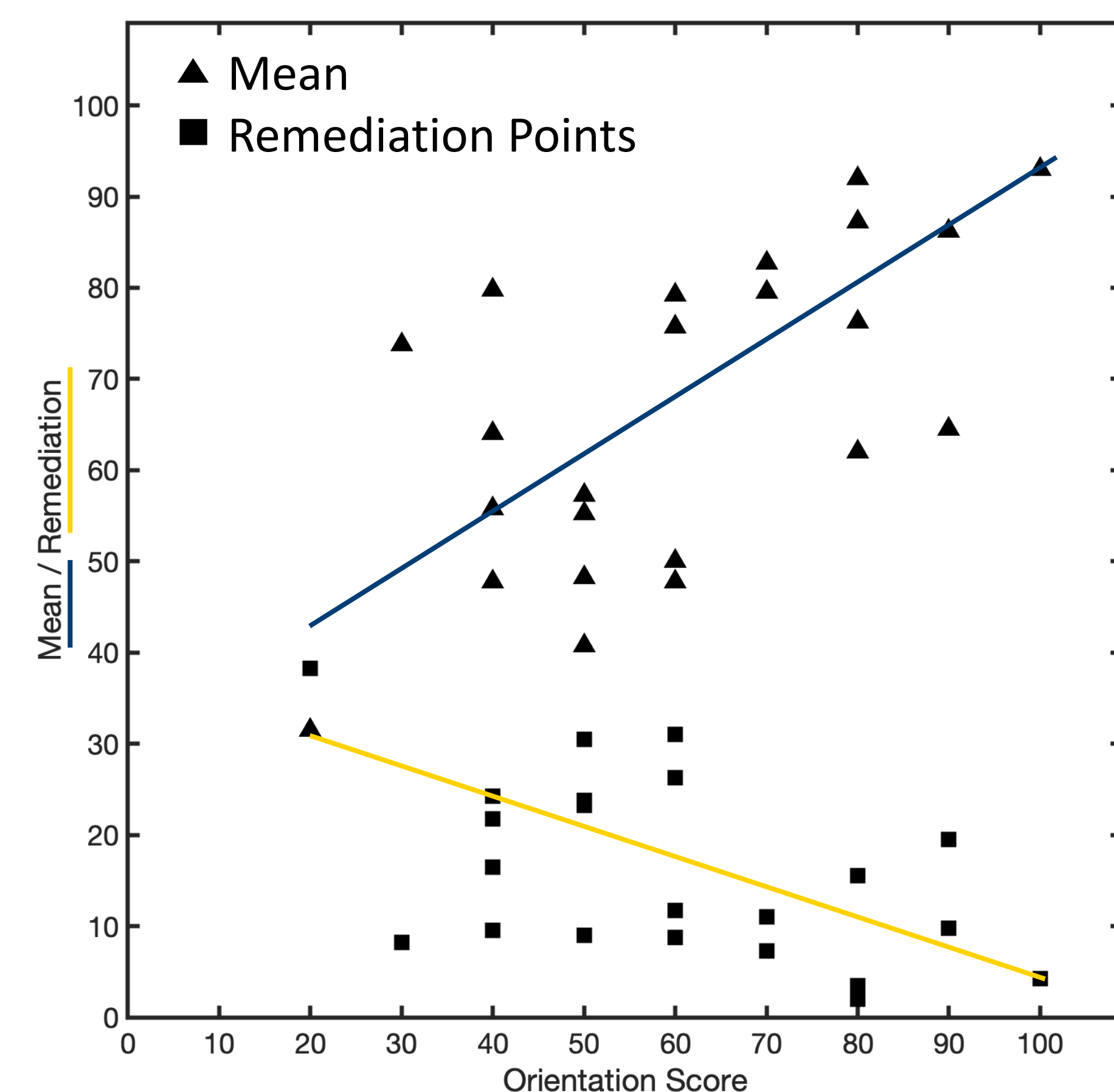


Figure 4: Relationship between orientation score and the impact of remediation ($r=-0.8$). Low-performers were able to recoup more points during remediation than high performers.

Results: 23/36 P1 students were followed throughout the study. The exclusion criteria for the remaining 15 students were: deceleration (2), absence of completed orientation quiz (13). We found a strong Pearson correlation between the pre-course score and:

- Overall course performance ($r=0.7$, Fig. 1).
- Need for metacognitive remediation ($r=-0.8$, Fig. 4).

We also found that:

- Cohort score variance reduced during the course, indicating a ceiling effect and significant learning in the less-able students (Fig. 2).
- Remediation was effective at developing the student's metacognitive skills to understand their blindspots and focus on improving their practice (Fig. 3).
- Rank order was modestly preserved for closed book quizzes, but was lost when tests were conducted in "open-book" conditions.
- All students who passed the orientation quiz were able to complete all formative exams without the need for remediation.
- All students who failed the orientation quiz needed to undergo 1-4 instances of remediation to pass the courses.
- The top 10-performing students at orientation significantly outperformed the bottom 10 students throughout the course ($p<0.001$) for the entirety of the courses.

Conclusion: Both overarching hypotheses for our study were supported by our findings. Teaching critical thinking skills and practicing NAPLEX-like questions were effective in improving student ability. Nevertheless, students with weak math skills consistently placed at the lower end of class and needed remediation to complete the course. These findings support the early detection of math deficits and need for readiness enhancement prior to the course.