Designing Classroom Performance Improvement Based Upon Metacognition. How We Improved Our Entire Class by 6% and the Bottom Quartile by More than 22%.

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In an effort to improve success rates in our large general chemistry sections at the University of Utah, it became apparent that the key component of success was improving the performance of the bottom two student quartiles. One factor that has been noted in chemical education research as hampering these students' abilities is poor metacognitive awareness, as evidenced by over prediction of their ability according to the Dunning-Kruger effect.[1-4] To meet this need, we implemented inside our homework system an effort to train students in improving their metacognitive ability. We hypothesized that improving low-performing students' metacognitive ability would result in improved student performance.

In fall semester 2016 we required students in one of our general chemistry sections to predict their scores prior to taking weekly quizzes as well as practice tests before each midterm exam and before the final exam. After every quiz and practice test, students were given feedback on their ability on each assessment topic. Using this information, students were asked to note areas of weakness and strength on the assessments. Additionally, on the practice tests, they selected topics that they would focus their studying upon. In a control section, students completed the same quizzes and practice tests, received the same feedback, but did not predict their scores, note areas of weakness, or select topics to study. To standardize our results from one year to the next, an American Chemical Society nationally normed final exam was used as a reference for how our students perform relative to the rest of United States. Analysis of results on the final exam demonstrated that the treatment section did, on average, 9.1 percentile better than the control section. After factoring out the effect of different teaching styles and incoming student ability, the metacognitive training appears to have improved student final exam performance by a statistically significant 6 percentile. Further analysis demonstrated that while student performance significantly improved in all of the treatment class quartiles, the largest change occurred in the lowest quartile. For these students there was a 23.3 percentile improvement on the final exam. After factoring out the effect of different teaching styles, the metacognitive training appears to have improved these students' final exam score by a statistically significant 15 percentile. Overall, the students in the treatment section scored on average at the 82nd national percentile, and the lowest quartile of students scored at the 53rd percentile, 3 percentile on average above the national average.

In this paper we will demonstrate how these changes were implemented, show the data for each comparison point, and explain what our results indicate about future directions in our research. Significantly, this research represents practical and easily implemented exercises that can be utilized at other institutions.

1. Kruger, J.; Dunning, D. *Journal of Personality and Social Psychology*, **1999**, *77*, 1121-1134.
2. Pazicni, S.; Bauer, C.F. *Chem. Educ. Res. Pract.* **2014**, *15*, 24-34.
3. Hawker, M.J.; Dysleski, L.; Ricky, D. *J. Chem. Educ.*,**2016**, *93*, 832-840.
4. Ricky, D.; Stacy, A.M. *J. Chem. Educ.*,**2000**, *77*, 915-920.