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Training Elementary Math Students to Effectively Monitor Learning

Key words: self-regulated learning, math education, self-efficacy, metacognition

Innovative math thinkers, crucial for a modern STEM workforce, are those who take ownership of their learning. This ownership can be characterized as self-regulated learning (SRL): the ability to set goals, monitor progress toward these goals, and make adjustments when necessary to ensure achievement (Zimmerman, 2008). Fostering SRL is especially important in mathematics, where students who are unable to monitor understanding may miss foundational material needed for advanced concepts. My study will evaluate a method of training elementary math students to accurately monitor their own learning, and will investigate whether and how improvement in monitoring increases math achievement.

In order to monitor progress, and thus utilize SRL, a student must be cognizant of what she does and does not know. Such students are said to be *calibrated*, a skill many students lack (Stone, 2000). Accurate calibration has been correlated with high performance (Stone, 2000), but training and improvement in calibration does not necessarily lead to higher achievement (Zimmerman, 2008). Failure to show this causal connection may be due to the length of typical trainings—most are only for days or weeks, allowing inadequate time for students to practice and internalize monitoring skills (Huff & Nietfeld, 2009). One of the only studies to show a connection between calibration improvement and achievement involved a semester-long training of college students (Nietfeld, Cao, Osbourne, 2006). This training combined feedback *and* explicit instruction on calibration strategies, leaving an open question as to which particular element had the greatest impact. In contrast, to understand how to best train calibration and the mechanism through which it improves learning, my study involves a year-long training period testing the effectiveness of feedback alone. My study also concentrates on young learners in the context of their math class, a population and domain neglected in the calibration literature.

Improving SRL skills and key self-beliefs in young learners is especially important, as these are resistant to change later in life (Bandura, 1986). One such belief, *self-efficacy*, is related to achievement and career choice—poor self-efficacy is a factor thought to discourage women from STEM-related careers (Bandura, 1986). The Nietfeld et al. (2006) study presented self-efficacy as a possible mediating variable between calibration and performance improvement, but was unable to trace a significant path from calibration through self-efficacy to achievement. The authors note that this may be due to the non-cumulative nature of their training subject-matter and their use of a global self-efficacy measure—issues that will be corrected for in the present study by using math as a venue for training and as a context for self-efficacy measurement.

Research Questions: (1) Can young students be trained to be more accurate in their calibration judgments through practice with feedback alone? (2) Is improvement in calibration accuracy linked to improvement in performance? (3) Does improved self-efficacy mediate the relationship between improvement in calibration and performance?

Methods: These questions will be answered with 3rd and 4th graders using tools embedded in the MIND Research Institute's ST Math—individualized software that allows students to control their progress through the curriculum. ST Math has been associated with increased math achievement (*d*=.37) (Rutherford et al., 2010), but exploring student calibration within ST Math is a new area of research. Within ST Math, 60 quizzes throughout the year ask students to give confidence ratings about their answers by selecting a cheering (confident) or shrugging (not confident) icon for each question. This interface presents a novel way to approach the difficulty of training and assessing calibration with young children who struggle with traditional monitoring measures (Huff & Nietfeld, 2009). Students are given graphical feedback about their confidence calibration after each quiz, allowing them to practice their own evaluative skills. MIND has agreed to provide de-identified data on calibration (measured as proportion of correct predictions to number of questions) and performance for approximately 60,000 students in 500 California schools. The sensitivity of 60 calibration data points throughout the year will allow for a longitudinal investigation of student monitoring using student growth curves. This will provide detailed information on trajectories of change, a significant contribution to the calibration and SRL literature, which has previously only been studied through pre and post tests.

Change models will be used to assess relations between calibration and performance. Separate regressions will be run for two performance outcomes: change in state standardized test scores (CSTs) from prior to end of study year and change in quiz performance from beginning to end of year. Each will be regressed on change in calibration scores calculated from difference of average calibration between the first and last five quizzes. The large-scale data analysis for these questions will take place during the 2011 school year. To assess whether self-efficacy mediates the calibration/achievement relationship, the PALS math self-efficacy scales will be given to students in a sample of 10-15 local schools at the beginning and end of the following year. A Sobel-Goodman test will be performed to assess change in self-efficacy as a mediator between change in calibration and performance. All regressions will control for students nested within schools and include grade, gender, SES and English Language Learner (ELL) status as control variables. Results will be disseminated to the research and practice communities starting in 2011.

Anticipated Results: By presenting students with numerous instances of age-appropriate feedback and calibration practice across an extended period of time they should improve their quiz calibration, and this improvement should be related to both their quiz and CST performance. Although the previous research has only shown tenuous connections between self-efficacy and calibration (e.g., Nietfeld et al, 2006), due to the participants' young age and formative state of self-beliefs, I expect a stronger connection with self-efficacy within the current study data.

Broader Impacts: Calibration training is a means through which students can better learn how to evaluate their educational progress and become active self-regulated learners, and ultimately, competent mathematical thinkers. Providing feedback and practice with software presents an easy-to-implement intervention with the potential for impact on a grand scale. Improving calibration and self-efficacy may be especially important among girls, who often demonstrate poor calibration and low self-efficacy in math, and among poor performers, whose low achievement may be in part due to poor calibration from underestimation of problem difficulty (Bandura, 1986). Studying California schools allows investigation of these effects in a diverse population, including a high percentage of Latino, ELL and low-performing students.

I certify that this proposal represents my original work.

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