

Can Item Response Times Provide Insight Into Students' Motivation And Self-Efficacy In Math?

By James Soland



KEY FINDINGS

- Student response time on math questions is correlated with self-efficacy in mathematics. Correlations between the time students spent on math questions and their scores for self-efficacy and motivation are moderate for self-efficacy (0.22) and low for motivation (0.04), but the correlation between duration and self-efficacy is comparable in magnitude to correlations between SEL scores and achievement seen in other studies.
- The amount of time students spent on very difficult items is highly correlated with academic motivation and self-efficacy. Students with the highest self-efficacy spent nearly half a minute longer than students with the lowest self-efficacy on items that were the most difficult.
- Item response time and other assessment metadata may provide useful, new information about students' SEL competencies.

When a student takes a computer-based test, in addition to whether the response provided is correct or incorrect, the testing system often records additional data, like how long the student took to answer the question. Research has shown that such assessment metadata can provide important insights about student testing behavior that can be used to improve measurement of academic achievement. For example, a substantial body of work harnesses item response time data to identify rapid guesses, a disengaged testing behavior that can bias test scores¹, and to mitigate the measurement problems rapid-guessing can cause.

Can assessment metadata also provide useful insight into students' social-emotional learning (SEL)? Because SEL competencies, like creativity, communication, self-management, and motivation, are important for student success in school and beyond^{ii,iii}, educators and policymakers have a strong and growing interest in improving how we measure, understand, and support these skills. However, most studies of SEL rely on student surveys, which can be distorted by self-report bias and other issues. Because of these problems, researchers are seeking ways to supplement surveys by identifying measurable behaviors that are direct demonstrations of SEL constructs to help validate uses of scores from SEL surveys and as SEL data sources in their own right.

This study examined one potential source of information, item response time metadata, to understand if the amount of time students spend on math test questions (accounting for how challenging each question is for each student) tells us anything about the students' SEL, specifically their *instrumental motivation* and *self-efficacy* in mathematics.

Instrumental motivation measures how motivated students are in a subject and how much that motivation stems from their belief that the material is valuable for their future success.

Self-efficacy measures a student's confidence in his or her ability to attain an educational goal, such as the ability to do well on a test or earn good grades in a class.

There is growing evidence that SEL, test behavior, and other academic behavior and educational outcomes are interconnected in important ways. For example, students with lower scores on measures of conscientiousness more often skip survey questions^{iv}, and students with lower scores on self-efficacy more frequently rapidly guess on multiple-choice questions. Lower scores in these SEL skills are also associated with higher risk of broader academic disengagement, including a greater likelihood a student will drop out of school^v.

If students have higher self-efficacy and motivation in math, they tend to show greater effort and persistence on homework, in-class assignments, and other academic tasks.

Using response time, assessment data and SEL scores, this study explores two questions:

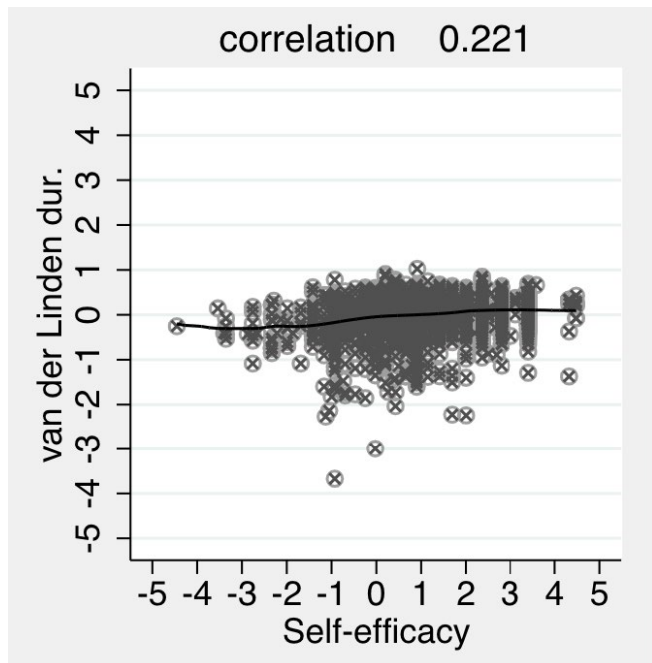
1. Is the amount of time that students spend on math test questions related to measures of their self-efficacy and motivation?
2. Do students spend longer on test questions that are very difficult relative to their achievement if they have higher motivation and self-efficacy?

To answer these questions, this study analyzed data from 5,192 students in 85 U.S. schools who took the Office for Economic Cooperation and Development (OECD) Test for Schools, an assessment measuring the knowledge of 15-year-old students in reading, mathematics, and science. The OECD Test for Schools also includes a student questionnaire that collects information about factors within and outside of school linked to student achievement, including certain SEL constructs. Because the test includes measures of both students' academic knowledge and of SEL, it provides a useful tool for exploring these questions.

Student response time on math questions is correlated with self-efficacy in mathematics.

The results showed that there are low to moderate correlations between the time students spent on math questions and their SEL scores. When accounting for item difficulty and student achievement, the average time a student spent on a test item was correlated with self-efficacy at 0.22 and motivation at 0.04.

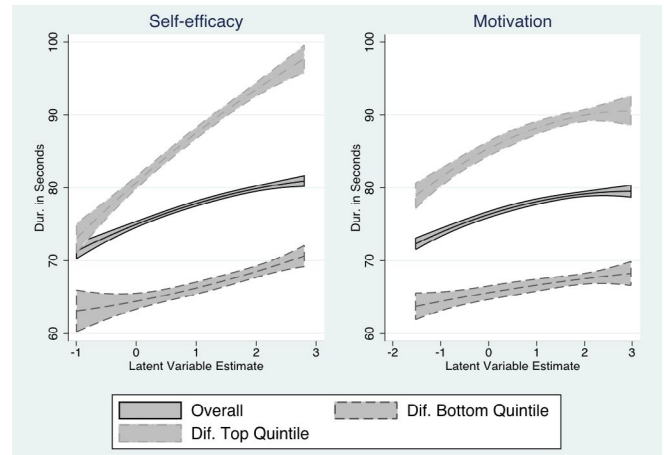
While these correlations are not high, the association between self-efficacy and duration is comparable in



Scatterplot of self-efficacy versus duration scores.

magnitude to correlations among SEL scores, as well as between SEL scores and achievement seen in other studies, which are often in the range of 0.1 to 0.3^{vi,vii}.

This finding suggests that, while person duration scores clearly are not ideal proxies for SEL constructs like motivation and self-efficacy, duration may provide some useful information on related SEL competencies, especially self-efficacy.



Polynomial fit to item-level duration (y axis) and SEL scores (x axis), overall and disaggregated by quintile of item difficulty adjusted for estimated achievement.

Students with higher motivation and self-efficacy spend longer on test questions that are very difficult relative to their achievement.

In general, students tended to spend longer on questions as difficulty increased relative to the student's estimated achievement.

Analysis showed that students with higher motivation and self-efficacy scores in general spent longer on math questions: students with the highest self-efficacy or motivation levels spent an average of about 10 seconds more per question than students with the lowest scores for these SEL constructs.

For the most difficult questions (the top 20 percent in difficulty), the differences in average item response time by SEL score were even greater. Students with the highest self-efficacy spent nearly half a minute longer on items that were difficult for them relative to students in the bottom quartile. Models revealed a significant interaction between self-efficacy and item difficulty, suggesting that students spent even more time on difficult items as their self-efficacy increased. A similar trend was seen for motivation, though to a smaller magnitude: students with motivation in the top quartile spent roughly 20 seconds longer on those most difficult items.

Therefore, this study provides preliminary evidence that students who are more motivated and have high self-efficacy are more likely to persist when confronted with test questions that challenge their understanding of the content. It also demonstrates that test behavior metadata, like item response times, may provide useful information for educators to supplement other assessments of students' social-emotional skills, or where SEL data is lacking, to help fill that void, if imperfectly.

RECOMMENDATIONS

For SEL, multiple measures matter: educators should consider the promise of test metadata as an additional source of information about students' SEL.

Because students' social-emotional competencies are important for their success in school and beyond^{viii, ix}, there is substantial and growing interest in education policy and practice in measuring, understanding, and supporting these skills. However, most studies of SEL rely on student surveys and so can be distorted by self-report bias and other issues.

This study shows that response process metadata may be a promising new source of information on students' SEL, though additional research is needed. For example, student response times on difficult items may be useful as a rough proxy for self-efficacy in the absence of survey data. Duration metadata could also help validate individual scores from SEL surveys: if a student reports high academic self-efficacy but spends relatively little time on very difficult items, then these contradictory behaviors may raise concerns about self-report bias on the survey or other forms of bias. Finally, research shows that educators may better support the development of SEL competencies if they have multiple measures of related constructs^x. Given that, additional data, like the metadata in this study, may help generate conversation between teachers and students about SEL, which can be a cornerstone for developing those competencies^{xi}. And, because these metadata are captured when a computer-based test is administered, time and cost required is minimal—an important consideration given the many demands on student and teacher time and educational resources.

But, educators should also be mindful of the limitations of test metadata as a measure of students' SEL.

While response process metadata hold promise, they are not designed to provide information on SEL, and many other factors play into student response processes. For example, while response times show a correlation with self-efficacy, they can also be influenced by contextual factors like the time of day the assessment is administered, or by factors unrelated to context. For example, a student may come up with a novel, efficient approach to solve an item more quickly, which would actually suggest high motivation and self-efficacy.

Additional problems may arise as more students and educators become aware of assessment metadata use: if students know that test metadata are being used to supplement SEL data, for instance, then they may behave in unforeseen ways that introduce even more bias than typically seen from the self-report bias in surveys, especially if stakes are perceived as higher. Given these complications, response process metadata might best serve as rough proxies for SEL constructs that can supplement more traditional data and possibly supply clues about whether self-report and other biases are impacting survey scores.

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