CARNEGIE LEARNING

MATHia® Performance & End-Of-Year Test Scores: A School District in Ohio (2021-2022 and 2022-2023)

Executive Summary

- MATHia is a computerized, adaptive learning tool for grade 6-12 mathematics. It is a key component of Carnegie Learning's blended, core curricula, Middle School Math Solution, and High School Math Solution. Years of research on the rich data generated by learners using MATHia have led to the Adaptive Personalized Learning Score (APLSE), a progress monitoring metric that is strongly correlated with performance on end-of-year assessments and interim assessments, year-over-year and across the country. These correlations suggest that the APLSE score is a high-quality predictor of end-of-year and interim assessment scores and that MATHia is an assessment of mathematics performance in its own right.

- An Ohio district provided data for 2,565 students from the 2021-2022 and 2022-2023 Ohio's State Tests (OST) . OST scale scores correlated strongly with MATHia achievement, as gauged by the APLSE score, ($r = .48$ to 0.79), depending on year, grade, and test. Every extra 10-point increase in APLSE points was associated with a 0.22 to 0.55 of a standard deviation increase in the end-of-year test scores depending on school year, grade, and test. Similar results have been seen across various states and districts for middle school and Algebra standardized tests.

Background

MATHia is Carnegie Learning's intelligent tutoring system for grades 6-12 mathematics. It offers guided instruction, tailored mastery exercises, and easy-to-understand reports for educators. Within MATHia, students progress through a series of multi-step math problems, organized into workspaces, which cover a complete course. MATHia collects extensive metrics on student effort and performance. As an adaptive instructional system, MATHia continually assesses student knowledge of fine-grained skills. MATHia's continuous assessment not only guides learning but can give us a comprehensive view of student math knowledge, which can be used to predict student performance on state end-of-year math assessments. Carnegie Learning reports the Adaptive Personalized Learning Score (APLSE), a composite score for progress monitoring that combines measures of the amount of time and number of problems required by students to complete and master MATHia workspaces, their skill mastery, and the number of errors students make and the help they request in MATHia workspaces. The score builds in comparisons of these measures with historical data. To obtain maximum benefit from the Middle School Math Solution and High School Math Solution, Carnegie Learning holds that students need to spend time working in MATHia, complete between 80-100 workspaces in an academic year, and eventually perform well on the embedded mathematics questions. Additionally, the APLSE score has been shown to predict scores on well-known interim assessments as well as end-of-year performance on state tests (Fancsali et al., 2018; Joshi et al., 2014; Ritter et al., 2013; Zheng et al., 2019)

The partner school district is a high-achieving district in Ohio. Approximately 81 percent of the population is White, 6 percent Black or African-American, 5 percent Hispanic or Latino, 6 percent Asian, and 3 percent Multi-Racial. Approximately, 6.5% of families live below the poverty level (National Center for Education Statistics, 2023).

Data & Analysis

Carnegie Learning partnered with an Ohio school district to analyze associations between usage and performance in its MATHia adaptive software and outcomes on the Ohio's State Tests (OST) for grades 6, 7, and 8, Algebra I and Geometry end-of-year tests during the 2021-2022 and 2022-2023 school years. The school district provided Carnegie Learning with data for 3,219 students who used MATHia and completed the 2021-2022 end-of-year tests and data for 2,325 students who used MATHia and completed the end-of-year 2022-2023 tests. Analyses included correlations between MATHia

achievement (measured using total APLSE points earned) and the OST scale scores and linear regressions predicting these scale scores from APLSE points earned.

Results

Analyses also indicated statistically significant correlations between APLSE scores and the OST scores (r = 0.48 to 0.79) depending on grade and school year (see Figure 1). In the regression analyses, every 10-point increase in APLSE scores was associated with a 4- to 15-point increase in end-of-year scale scores, which corresponds to a 0.21 to 0.55 increase of a standard deviation based on the sample.

Discussion

The correlations and regression results suggest that the APLSE score is a high-quality predictor of interim and end-of-grade test scores and that MATHia can function as an embedded, formative assessment. These correlations and regression results are consistent with numerous peer-reviewed findings associating usage and performance in MATHia with various standardized test score results across grade levels and states (see, e.g., Ritter et al., 2013; Fancsali et al. 2016, Zheng et al., 2019). The results are consistent with the interpretation that students who put their time in MATHia, do their MATHia assignments, and perform well on the MATHia questions will perform better on their MAP Growth and their end-of-year state tests. Experimental findings from large-scale randomized controlled trials also demonstrate the effectiveness of Carnegie Learning's curricula on instruction and student learning (Pane et al., 2014).

Carnegie Learning welcomes the opportunity to partner with your school to learn more about what's working in your classrooms! Contact your Carnegie Learning Representative to learn more.
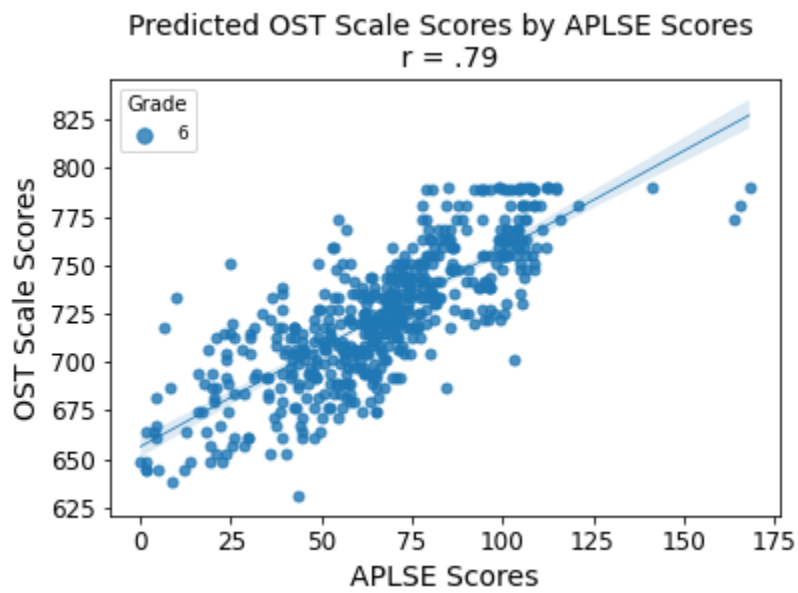
Figure 1. Scatterplot depicting relationship between APLSE points earned and Ohio's State Tests (OST) scores for Grade 6 in the 2022-2023 school year. Each point on the graph represents a student. Students who earned more APLSE points received higher scores on the OST.

References

Fancsali, S.E., Ritter, S., Yudelson, M., Sandbothe, M., Berman, S.R. (2016). Implementation Factors and Outcomes for Intelligent Tutoring Systems: A Case Study of Time and Efficiency with Cognitive Tutor Algebra. *Proceedings of the Twenty-Ninth International Florida Artificial Intelligence Research Society Conference*. (pp. 473-478). AAAI.

Joshi, A., Fancsali, S. E., Ritter, S., Nixon, T., & Berman, S. R. (2014). Generalizing and Extending a Predictive Model for Standardized Test Scores Based on Cognitive Tutor Interactions. In J. Stamper et al. (Eds.), *Proceedings of the 7th International Conference on Educational Data Mining* (pp. 369–370). International Educational Data Mining Society.

National Center for Education Statistics, Education Demographic and Geographic Estimates. (nd). *ACS-ED District Demographic Dashboard, 2017-2021*. National Center for Education Statistics. https://nces.ed.gov/Programs/Edge/ACSDashboard/3904373

Pane, J. F., Griffin, B. A., McCaffrey, D. F., & Karam, R. (2014). Effectiveness of cognitive tutor algebra I at scale. *Educational Evaluation and Policy Analysis*, 36(2), 127–144. https://dx.doi.org/10.3102/0162373713507480

Ritter, S., Joshi, A., Fancsali, S. E., & Nixon, T. (2013). Predicting standardized test scores from Cognitive Tutor interactions. In S. K. D'Mello et al. (Eds.), *Proceedings of the 6th International Conference on Educational Data Mining* (pp. 169–176). International Educational Data Mining Society.

Zheng, G., Fancsali, S.E., Ritter, S., Berman, S.R. (2019). Using Instruction-Embedded Formative Assessment to Predict State Summative Test Scores and Achievement Levels in Mathematics. *Journal of Learning Analytics*, 6(2), 153–174. http://dx.doi.org/10.18608/jla.2019.62.11