

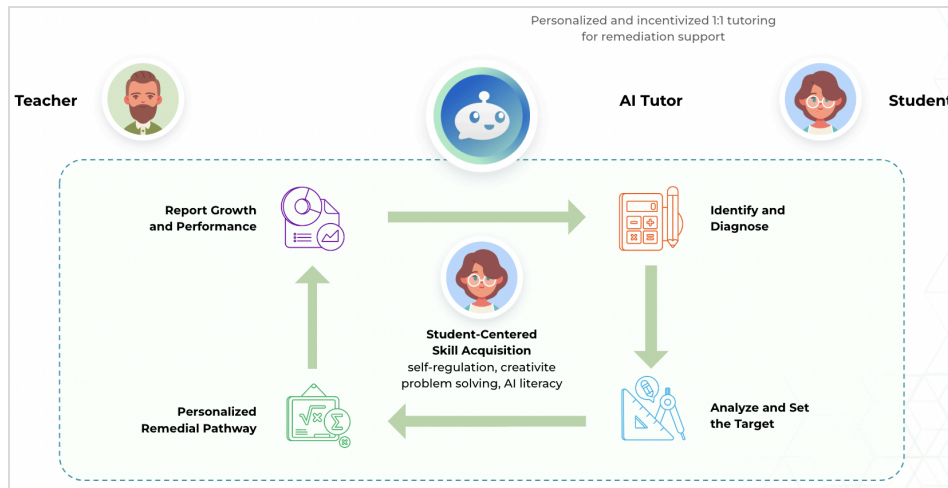
Evidence-based R&D Results in Using AI Math Pathway to Close Accumulated Math Skill Gaps in UAE K12 Education

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The United Arab Emirates has been very active in building domestic human capital for a competitive knowledge economy during the past decades. UAE Vision 2021 aims to build a first-rate education system, with emirati students ranked among the best in the world. However, based on the 2018 PISA report, UAE students' mean performance in reading, math, and science has been well below the OECD average since 2012, the gap between high-achieving and lowest achieving students widened in all three subjects. This implies that students have accumulated learning gaps before reaching the age of 15. We have further found that the average grade gap in Grade 9 is reaching -3.366, which means that on average, the actual math performance level of an average Grade 9 student equals that of a fifth grader reaching the seventh month of the academic year.

To solve this problem, we have designed and developed a student-facing AI-powered math pathway for Grade 5 to Grade 12 UAE public school students. Students start the journey by taking an adaptive test that diagnose learning gap in both math and english reading, as english reading is found to be the No. 1 factor affects students math learning; then each learner is recommended with a personalize remediation pathway by setting reasonable targets and goals to complete lessons that aim at math power skills in the format of bite-sized localized instructional video, interactive questions, formative and interim assessments. English content level is tailored for student levels. During the remedial journey, an AI dialogue-based tutor is designed to help students if there are misconceptions or questions. The goal is also to foster skills such as self-regulation and problem solving. Then, learner progress reporting including growth, performance and gaps will be reported to the teacher and reflected on the learner profile for further action. Below is a visual of the math pathway. One of the key functionalities in the backend is knowledge graph connecting math power skills, tagged with instructional content and assessments. This is because students have accumulated a math skill gap over years and it is key to tackle the most important skill gap to move to higher levels.

The key AI functionalities are enabled by rich data on assessments aligned with metometrics international scale, remedial content pool, knowledge graph of power skills, metadata tagging, learning analytics dashboard, and dialogue-based Tutor AI pedagogical agent. (See below a visual of the math pathway).



In order to understand the impact of the pathway on student math learning outcomes, an initial pilot study was conducted among Grade 5 to Grade 8 UAE public school students from September 2022 to July 2023. 1800 students across Grade 5 to grade 8 have access to the pathway program. We used propensity score matching technique to create control groups who are not using pathway programs based on the following key indicators: a. school organization (i.e. same school governance, curriculum standards and instruction language for math), b. Grade level, c. pre-diagnostic test results (i.e. T1). Post-matching, we identified two groups: the treatment group, with 318 students actively engaged with the pathway program (i.e. completing over 10 pathway levels), and a Control group (with 319 students who do not use pathway). To ensure robust and accurate results, diagnostic tests from students who spent less than 15 minutes were excluded from the final analysis. By examining student diagnostic test data between control and treatment from Sept. 2022 (T1) to July 2023 (T2), we examine the change in math performance change. The Propensity Score Matching achieved a balanced comparison, as indicated by minimal absolute mean differences between groups. Results showed that students who are engaged actively with the pathway program experienced a 5.97% performance uplift in diagnostic tests (P-value = 0.0048, 95% Confidence Interval [527.5, 558.4]), and a growth uplift of 38.42% compared to the control group (P-value = 0.015, 95% Confidence Interval [73.58, 101.49]).

These results show significant improvement in closing student math skill gaps within the UAE K12 education system, and to help improve the efficiency and effectiveness of learning through AI-powered diagnostic, remediation and personalized tutoring support ecosystem. In the near future, we aim to investigate the impact of AI tutoring interactive features that are intended to foster problem solving, self-regulation and AI literacy skills. Building a holistic learner profile and skill development is a key consideration for our research and development efforts in AI education.