Closing the Achievement Gap in STEM: The Influence of Prior Knowledge on the Guidance Effects in Technology-Based Guided Student-Centered Learning

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As the U.S. is falling behind in STEM education and struggling with the achievement gap, there have been many practical obstacles concerning teachers and existing multimedia tools in implementing research-recommended guidance in student-centered learning (SCL) into classrooms. Based on the Cognitive Load Theory, meta-analytic findings, and my original prototypes, I fully implemented an innovative web-based instructional tool that combined expertise from educational research and best teaching practices to overcome these obstacles and enhance Guided-SCL in chemistry. College students (N = 185) were randomly assigned to Guided-SCL or either of two control groups and were given pre-posttests and one month follow-up tests, resulting in the following key findings: (a) Guided-SCL significantly outperformed traditional direct instruction (d = 1.60, 262% increase) and Khan Academy (d = 1.42, 185% increase) with long-term effects; (b) Guided-SCL fully closed the achievement gap between students with low prior knowledge (LK) and high prior knowledge (HK) for both conceptual and procedural knowledge; (c) Consistent with the Expertise Reversal Effect, prior-knowledge activation significantly benefited LK (d = 0.84) with long-term effects but harmed HK (d = -0.46); (d) Feedback timing (immediate vs. delayed) made no difference for LK and HK when explanatory feedback was also provided. This novel work in chemistry classrooms provides the greatly-needed empirical data supporting guidance in SCL and contributes new insight towards more effective and adaptive instructional designs. By translating research into practice, this study demonstrates the great potential of using innovative research-based technology to close the achievement gap and improve STEM education in the U.S.