Re-Engineering Digital Assessments: A Multi-Modular HCI Framework for Minimizing Cognitive Load in Standardized Testing Through CLT-Driven Interface Redesign

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Standardized testing is a critical tool in evaluating the academic ability of over 40 million U.S. students. Assessments are a pillar of the education system, influencing policy, and national resources. However, existing tests fail to adapt instructional theories to maximize performance, leading to miscalculations of academic ability. By introducing Cognitive Systems Engineering (CSE), testing platforms were redesigned to cater to the cognitive needs of students. This project proposes an algorithmic framework and system structure to quantify and optimize cognitive load (CL) in virtual assessments. Through evaluating widely used test platforms, comprising over 75% of U.S. educational digital assessments, usability flaws were identified. A proxy was constructed to measure working memory distribution, and quantified CL through mathematical modeling resulting in predictive performance metrics. This was applied to an adaptive algorithm for evidence-based instructional theories (e.g., modality effect), targeting Nielson's usability heuristics, and modular user interface applications. Two prototypes were developed: (1) a control model replicating existing platforms and (2) a revised model incorporating scientifically backed solutions. CL was evaluated through multivariate statistical analyses and cross-validated using the proxy model. Results reflected a 6.2% increase in accuracy, a 10.8% decrease in time, and an 8.5% decrease in CL. These findings indicate that Cognitive Systems Engineering (CSE) holistically improves test performance, establishing standardized testing as an evidence-based environment designed to accurately reflect student ability. This contributes to widespread use across various assessment sectors with far-reaching implications for educational equity.

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