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DEVELOPING ALGORITHMIC THINKING AND DIGITAL COMPETENCE IN MEDICAL STUDENTS THROUGH STRUCTURED DIDACTIC TECHNOLOGIES

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Abstract

This two-center controlled study will test algorithm-oriented digital teaching in 624 medical students in Uzbekistan (324 intervention, 300 control). The intervention combines clinical algorithms, decision trees, virtual patients, formative digital assessment, collaborative learning, and reflection. Controls receive conventional teaching. The primary outcome is OSCE performance. In pilot data, the digital group scored higher on the OSCE (82.4 ± 6.8 vs 71.6 ± 7.5; mean difference 10.8, 95% CI 8.57–13.03; $p < 0.001$) and on the cognitive composite (112.3 ± 9.4 vs 104.7 ± 10.1; $p < 0.001$).

Keywords: algorithmic thinking, digital competence, clinical reasoning, medical education, didactic technologies, OSCE, virtual patients, Uzbekistan

Background. Digital health is expanding, and future physicians must combine clinical knowledge with algorithmic reasoning, information appraisal, digital professionalism, and safe use of health technologies. The international DECODE framework sorts undergraduate digital-health competence into four domains: professionalism, patient and population digital health, health information systems, and health data science [1]. It supports teaching these domains inside the curriculum. Earlier work at the Fergana Medical Institute of Public Health (FMIOPH) used clinical algorithms, decision trees, virtual patients, formative digital assessment, and structured reflection to connect digital competence with clinical decision-making [2].

Objective. To test whether an algorithm-oriented digital didactic model is linked to better clinical reasoning, diagnostic sequencing, and digital competence than conventional instruction in medical students from two institutions in Uzbekistan.

Methods. This is a planned two-center controlled quasi-experimental study of 624 mentally and physically healthy undergraduate medical students. At FMIOPH, 324 students will receive the intervention. At Andijan State Medical Institute, 300 students will form the external control group. Both groups will study the same academic module. The intervention group will complete algorithm-based clinical cases, digital decision trees, virtual-patient tasks, collaborative problem solving, learning-management-system activities with formative feedback, and structured self-reflection. Controls will follow the standard lecture, seminar, printed-material, and non-digital case-discussion curriculum.

The primary outcome is total performance in a standardized 10-station Objective Structured Clinical Examination (OSCE; range 0–100). Secondary outcomes are clinical-reasoning, diagnostic-sequencing, digital-tool-use, decision-accuracy, and time-management scores, plus a standardized digital-competence composite. Assessors will be blinded to study group, and both institutions will use identical rubrics. Digital problem-based learning has shown advantages over traditional teaching for knowledge and smaller benefits for skills [3]. Virtual-patient reviews suggest that gains are more consistent for case-specific reasoning than for broad problem solving [4].

Continuous variables will be reported as mean ± standard deviation (M ± SD) and categorical variables as n (%). Baseline balance will be evaluated with standardized mean differences. The primary analysis is an analysis of covariance: post-intervention OSCE score is the dependent variable, study group is the exposure, and baseline OSCE, age, sex, academic year, and prior digital-training

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experience are the covariates. Results will include adjusted mean differences, 95% confidence intervals (CI), p values, and Hedges' g. Sensitivity analyses will use Welch's independent-samples t test and compare complete-case with multiply imputed datasets. Two-sided $p < 0.05$ will indicate statistical significance. With 324 intervention and 300 control participants, the design has about 80% power at $\alpha = 0.05$ to detect a standardized between-group difference of about 0.225.

Pilot results. The pilot study compared 79 students who received algorithm-oriented digital instruction with 79 who received conventional teaching. Mean total OSCE performance was 82.4 ± 6.8 versus 71.6 ± 7.5. The unadjusted mean difference was 10.8 points (95% CI 8.57–13.03; Hedges' $g = 1.50$; $p < 0.001$). The standardized cognitive composite was 112.3 ± 9.4 in the intervention group and 104.7 ± 10.1 in controls, a difference of 7.6 points (95% CI 4.56–10.64; Hedges' $g = 0.78$; $p < 0.001$). High-level algorithmic-reasoning performance appeared in 34.2% of intervention students and 17.7% of controls [2].

Discussion. The pilot differences are large for applied clinical performance and moderate to large for the cognitive composite. That supports validation in a much larger cohort. The direction matches earlier evidence: digital problem-based learning can improve knowledge and skills [3], virtual patients may strengthen case-specific clinical reasoning [4], and virtual-reality instruction can improve knowledge and cognitive skills [5]. The new design has one weak point. It assigns conditions by institution, so institutional culture, admission profiles, instructor effects, infrastructure, and curriculum differences remain confounded with exposure even after statistical adjustment. Unless both institutions contribute students to both instructional conditions, or allocation happens at class or student level, the findings will be read as adjusted associations.

Conclusion. Algorithm-oriented digital didactic technologies look like a promising way to join clinical reasoning with digital-health competence. The planned 624-student comparison will show whether the pilot signal holds up and how precise it is. Causal claims need stronger allocation procedures, harmonized assessment, blinded scoring, and full reporting of missing data and protocol deviations.

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