SIMULATING INDIVIDUAL TRAJECTORIES OF TEACHER-LED EDUCATIONAL INNOVATION ADOPTION: A LOGISTIC ORDINARY DIFFERENTIAL EQUATION MODEL WITH INTERVENTION ANALYSIS

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Abstract - This study proposes a personalized logistic ordinary differential equation (ODE) model to simulate individual teacher trajectories of inquiry-based learning (IBL) adoption over time. Cross-sectional frameworks identify predictors of current implementation but cannot answer whether a given teacher will sustain or abandon inquiry practice in the future. For each teacher i, inquiry propensity Q(t) evolves as $dQ/dt = rQ(1-Q) + \alpha I + \beta C + \gamma V + \delta S + \eta E - \lambda Q$, incorporating autonomous saturation dynamics, exogenous forcing by five covariates (inquiry image, pedagogical confidence, perceived importance, ICT skill, self-efficacy), and institutional decay. The stable equilibrium Q* classifies teachers into High (Q* >0.7), Conditional (0.3–0.7), or At-Risk (≤ 0.3) sustainability groups. Simulation using a dummy dataset (N = 1,000) suggested the possibility of latent adoption potential concealed by static measurement. A counterfactual ICT augmentation ($\Delta S = +0.2$) raised mean equilibrium by $\Delta Q = +0.036$, while collective diffusion analysis identified a critical threshold beyond which system-wide adoption becomes self-sustaining. The model is intended as a theory-driven simulation framework and establishes the ODE layer as the mesoscopic bridge within the broader Educational Statistical Mechanics (ESM) framework.

Keywords: Educational statistical mechanics, Ordinary differential equation, Inquiry-based learning, Teacher adoption, Individual trajectory simulation, Intervention analysis, Logistic growth model, Self-efficacy, ICT integration, Innovation diffusion