**ODD+D Protocol for Parental Learning Strategies and Time Investment Model**

**Overview**

**Purpose**:

To explore how parental education levels and social networks influence learning strategies (individual vs. social learning) and time investment in children. The model incorporates adjustable parameters to simulate various demographic scenarios and social learning strategies, providing a comprehensive analysis of parental decision-making processes.

**Entities, State Variables, and Scales**:

• **Agents**: Represent parents.

• **Education Level**: Low, Medium, High.

• **Learning Strategy**: Individual, Social.

• **Time Investment**: Minutes spent with children.

• **Child Outcome Score**: Evaluates the effectiveness of time investment.

• **Environment**: Watts-Strogatz small-world network.

• **Time Steps**: Discrete steps representing time periods (e.g., days, months).

**Process Overview and Scheduling**:

• At each time step:

• Agents observe peers’ strategies and time investments.

• Agents update their learning strategies based on peer influence and child outcome scores.

• Agents adjust their time investment based on feedback.

**Details**

**Initialization**:

• **Agent Density**: Adjustable via GUI, allowing the grid to be partially filled.

• **Education Levels**: Adjustable ratios of low, medium, and high education levels.

• **Initial Learning Strategies**: Adjustable ratios of social and individual learning within each education level.

• **Social Learning Strategies**: Adjustable ratios of three strategies within each education level:

• Copying the highest-scoring neighbor.

• Copying the most frequently observed strategy.

• Copying randomly.

**Input Data**:

• Parameters for network creation and agent attributes:

• **Number of agents (N)**

• **Average node degree (k)**

• **Rewiring probability (p)**

• **Grid dimensions (width, height)**

• **Initial density of agents**

• **Ratios for education levels**

• **Ratios for initial learning strategies**

• **Ratios for social learning strategies**

• **Discrepancy thresholds for switching learning strategies**: Adjustable for each education level.

• **Probabilities for switching learning strategies**: Adjustable for each education level.

**Submodels**:

1. **Learning Strategy Update**:

• **Objective**: To determine whether an agent should update its learning strategy based on peer influence and feedback.

• **Process**:

1. **Gather Information**: Observe peers’ strategies.

2. **Assess Influence**: Calculate the proportion of neighbors using social learning.

3. **Decision Rule**: Compare to thresholds to decide on switching strategies:

• High-education agents require a higher proportion to switch.

• Medium-education agents have a moderate threshold.

• Low-education agents have a lower threshold.

2. **Time Investment Decision**:

• **Objective**: Adjust time investment based on feedback.

• **Process**:

1. **Individual Learners**: Set investment using internal rule.

2. **Social Learners**: Average peers’ investments.

3. **Feedback Loop**: Adjust investments based on child outcome scores.

• **Optimal Range**: Define range where scores are maximized.

• **Positive/Negative Feedback**: Adjust investments to stay within optimal range.

3. **Child Outcome Score**:

• **Calculation**: Score based on whether time investment is within optimal range.

• **Impact**: High scores reinforce current strategy; low/no scores prompt reassessment.

4. **Switching Threshold Based on Discrepancy**:

• **Logic**: Making the switch from individual to social learning dependent on the discrepancy between actual and optimal time investment, with different thresholds for each education level.

• **Feasibility**: Define different thresholds and probabilities for each education level:

• **High-Education Parents**: Have a low probability of switching but are triggered by a small discrepancy.

• **Medium-Education Parents**: Have moderate thresholds and probabilities.

• **Low-Education Parents**: Switch more easily with larger discrepancies.

**Decision (D)**

**Agents’ Decision-Making**:

The decision-making process in the model focuses on how agents determine their learning strategy and time investment. This process is influenced by both their own characteristics (education level) and the behaviors observed in their social network.

1. **Initial Decision**:

• Based on education level, agents start with an initial learning strategy.

2. **Dynamic Decision-Making**:

• Agents reassess their learning strategy based on peer influence and child outcome scores.

• Probabilities for switching strategies vary by education level, with high-education parents having lower probabilities but being sensitive to smaller discrepancies.

• Discrepancy between actual and optimal time investment influences the likelihood of switching strategies.

3. **Time Investment**:

• Adjusted based on feedback from the child outcome score.

**Example Scenario of Operation**

1. **Initialization**:

• Create 100 agents with random education levels.

• Generate a Watts-Strogatz network.

• Assign initial learning strategies and time investments.

2. **Simulation Loop**:

• **Step 1**: Agents observe peers’ strategies.

• **Step 2**: Calculate child outcome scores based on time investment.

• **Step 3**: Update learning strategies based on peer influence, scores, and discrepancy thresholds.

• **Step 4**: Adjust time investments to maximize scores.

**Feasibility**

The proposed updates are feasible within the Mesa framework. The flexibility of Mesa supports dynamic agent-based modeling, adjustable parameters, and real-time feedback mechanisms, making it well-suited to implement the described modifications. The GUI can be enhanced to include sliders for adjusting initial conditions, learning strategies, and thresholds for switching strategies, providing a user-friendly interface for exploring different scenarios and their outcomes.