# RESEARCH TRIAL PROTOCOL

**Protocol Title:**

Mixed Reality Adaptive Learning Environments for Improving the Digital Quality of Life of Students with Intellectual Disabilities

**Principal Investigator:**

Abdellah Ibrahim Mohammed Elfeky

**Affiliation:**

*King Salman Center for Disability Research, Riyadh 11614, Saudi Arabia*

**Trial Sponsor/Approval Body:**

Directorate of Special Education, Ministry of Education, Jeddah, Saudi Arabia.

**IRB Approval Reference:**

JED-SE-2026-ETH-094

**Protocol Version & Date:** Version 1.2 – June 2026.

## 1. General Information

- **Protocol Title:** Mixed Reality Adaptive Learning Environments for Improving the Digital Quality of Life of Students with Intellectual Disabilities
- **Principal Investigator:** [Abdellah Ibrahim Mohammed Elfeky]
- **Affiliation:** [*King Salman Center for Disability Research, Riyadh 11614, Saudi Arabia*]
- **Trial Sponsor/Approval Body:** Directorate of Special Education, Ministry of Education, Jeddah, Saudi Arabia.
- **IRB Approval Reference:** JED-SE-2026-ETH-094
- **Trial Registration Identifier:**
- **Protocol Version & Date:** Version 1.2 – June 2026.

## 2. Project Summary and Objectives

The purpose of this behavioral intervention trial is to examine the efficacy of an Adaptive Mixed Reality Learning Environment (AMRLE) against conventional screen-based assistive technologies. The primary objective is to evaluate whether integrating dynamic algorithmic micro-scaffolding based on eye/hand tracking metrics can systematically enhance the multi-dimensional constructs of Digital Quality of Life (DQoL) for educable adolescents and young adults with mild-to-moderate intellectual disabilities (ID).

## 3. Study Design and Methodology

### 3.1 Trial Design

This study is structured as a **Quasi-Experimental Pretest-Posttest Control Group Design**. Due to institutional regulations within the specialized education centers in Jeddah and the ethical necessity of maintaining intact classroom ecological validity, a true randomized controlled trial (RCT) layout was modified to a matched-pair allocation framework.

### 3.2 Participant Recruitment and Selection

- **Setting:** Resource rooms inside certified special education complexes in Jeddah, Saudi Arabia.

- **Target Sample Size:** ($N$ = 44) participants ($n$ = 22) Experimental Group; ($n$ = 22) Control Group), determined via a prospective power analysis (G*Power) assuming a large effect size ($f$ = 0.40), ($\alpha$= 0.05), and power (1-β) = 0.85).

**Inclusion Criteria:**

1. Chronological age formally documented between 10.0 and 20.0 years.
2. Documented diagnosis of Mild-to-Moderate Intellectual Disability based on the DSM-5 criteria, verified by the Saudi Commission for Health Specialties.
3. IQ range between 50 and 69 measured via the standardized Arabic versions of the Stanford-Binet or WISC-V scales.
4. Classified as "Educable Intellectual Disability" under the Saudi educational framework.

**Exclusion Criteria:**

1. Co-occurring severe neurodevelopmental conditions (e.g., profound Autism Spectrum Disorder).
2. Medical history of photosensitive epilepsy or severe vestibulo-ocular reflex disorders.
3. Absence of functional verbal comprehension in Arabic.

## 4. Intervention and Execution Plan

### 4.1 The Experimental Arm (AMRLE Group)

Participants in the experimental group will engage with the **Adaptive Mixed Reality Learning Environment** delivered via high-fidelity pass-through MR headsets (e.g., Meta Quest 3). The intervention spans **8 weeks**, consisting of **three 20-minute individual sessions per week** (24 sessions total).

**The Algorithmic Adaptivity Loop:**

The software (developed in Unity 3D) runs an automated state machine monitoring two real-time metrics: **Response Latency (TL)** and **Error Frequency (EF)**. If a user exhibits delayed engagement (TL > 15 seconds) or commits repetitive mistakes (EF ≥ 2), the adaptive engine executes:

1. *Visual Pruning:* Fading out secondary or peripheral objects to reduce cognitive load.
2. *Multimodal Scaffolding:* Rendering a glowing neon-green tracking vector path towards the target action, paired with slow, clear audio guidance in the local Saudi dialect.

### 4.2 The Control Arm (Conventional Technology Group)

Participants in the control group will target identical learning domains (autonomous interface navigation, digital safety recognition, and interface engagement) using a conventional, non-adaptive screen-based tablet interface. The instructional dosage (20-minute sessions, 3 times a week for 8 weeks) and environmental configurations (identical quiet resource rooms in Jeddah) will be strictly matched with the experimental group to isolate the spatial adaptivity treatment effect.

## 5. Ethical Considerations and Safety Monitoring

### 5.1 Informed Consent and Assent

- Written formal **Informed Consent** will be secured directly from the parents/legal guardians of the minor participants before baseline measurement.
- Visual and verbal **Assent** will be obtained from the students using simplified pictographic cards.
- Explicit parent/guardian consent will be secured for publishing any illustrative software interaction graphics in open-access formats (de-identified to protect anonymity).

### 5.2 Safety and Trial Discontinuation Protocols

The MR headsets will be calibrated per user to establish correct arm-reach envelopes. The resource room will feature a pre-cleared physical boundary of (3 × 3) meters. If a student displays physical markers of tech-distress (e.g., hand tremors, attempts to remove the headset, verbal avoidance), the system immediately triggers a "Cool Down" sequence (low-frequency ambient particles), and the instructor will terminate the session. Participants retain the absolute right to withdraw at any time without penalty.

## 6. Data Management and Statistical Analysis

### 6.1 Assessment Instruments

1. **Digital Quality of Life Observation Scale (DQoLOS):** A 16-item behavioral scale scored on a 3-point Likert configuration, covering Digital Autonomy, Safety, Well-being, and Inclusion (S-CVI = 0.93; Cronbach's ($\alpha$ = 0.89).
2. **Automated Telemetry Logs:** Computerized tracking of exact Response Latency (in seconds) and Cumulative Errors recorded frame-by-frame by the adaptive engine.

### 6.2 Analysis Plan

Data analysis will be performed using IBM SPSS Statistics (v.29). A one-way **Analysis of Covariance (ANCOVA)** will evaluate posttest scores between the groups, using the pretest baseline scores as the continuous covariate to isolate treatment variance. **Partial Eta Squared ($\eta^2$)** will quantify the practical effect size. Within-group longitudinal performance alterations in system telemetry will be analyzed via **Paired-Sample (t)-tests** or non-parametric **Wilcoxon Signed-Rank tests** depending on Shapiro-Wilk normality profiles.