

Orchestrating the STEAM Box

Reducing Facilitator Load with Guiding Technology

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The Overture

Context: High-Tech Science in Remote Communities. The “From Waste to Wisdom” STEAM Box is a modular learning kit designed for the Goodwill STEAM Box Program. This kit is shipped to remote counties to engage middle school students in the Socio-Scientific Issue (SSI) of food waste through fermentation experiments.

The Problem: Extrinsic Constraints. The program relies on community volunteers who often don't have formal science and pedagogical training. They have to face severe “extrinsic constraints” such as limited time, lack of scientific expertise, and the chaos of managing active group work.

The Challenge: Orchestration Load. Defined as “the real-time cognitive and physical effort a teacher spends in coordinating multiple activities and learning processes.” Without support, the cognitive load of managing the box & classroom at the same time overwhelms the volunteer and leads to a chaos.



The Score

The 4-Phase Macro-Script. The curriculum acts as a Macro-Script to structure the flow, ensuring consistency for all sites:

- 1. Exploration (AI Analysis):**
 - **Activity:** Students photograph & categorize cafeteria waste.
 - **Orchestration:** “**Sorting Agents**” group students based on interests (e.g., Fruit Group vs. Vegetable Group).
- 2. Experimentation (The Lab):**
 - **Activity:** Students brine vegetables, install sensors, monitor fermentation.
 - **Orchestration:** “**Consensus Agents**” prevent movement to the next step until safety checklist is verified.
- 3. Connection (Plane Shift):**
 - **Activity:** Interviewing elders about food heritage.
 - **Theory:** Managing the transition from group work (π_2) to community engagement (π_3).
- 4. Showcase (Publication):**
 - **Activity:** Teams publish recipes to the “Living Cookbook.”
 - **Orchestration:** “**Visualization Agents**” automatically aggregate group data into a community knowledge base.

The Tempo

The Intervention: A “Guiding” Dashboard to address the “**Teaching Paradox**”. The system uses technology to manage the class tempo.

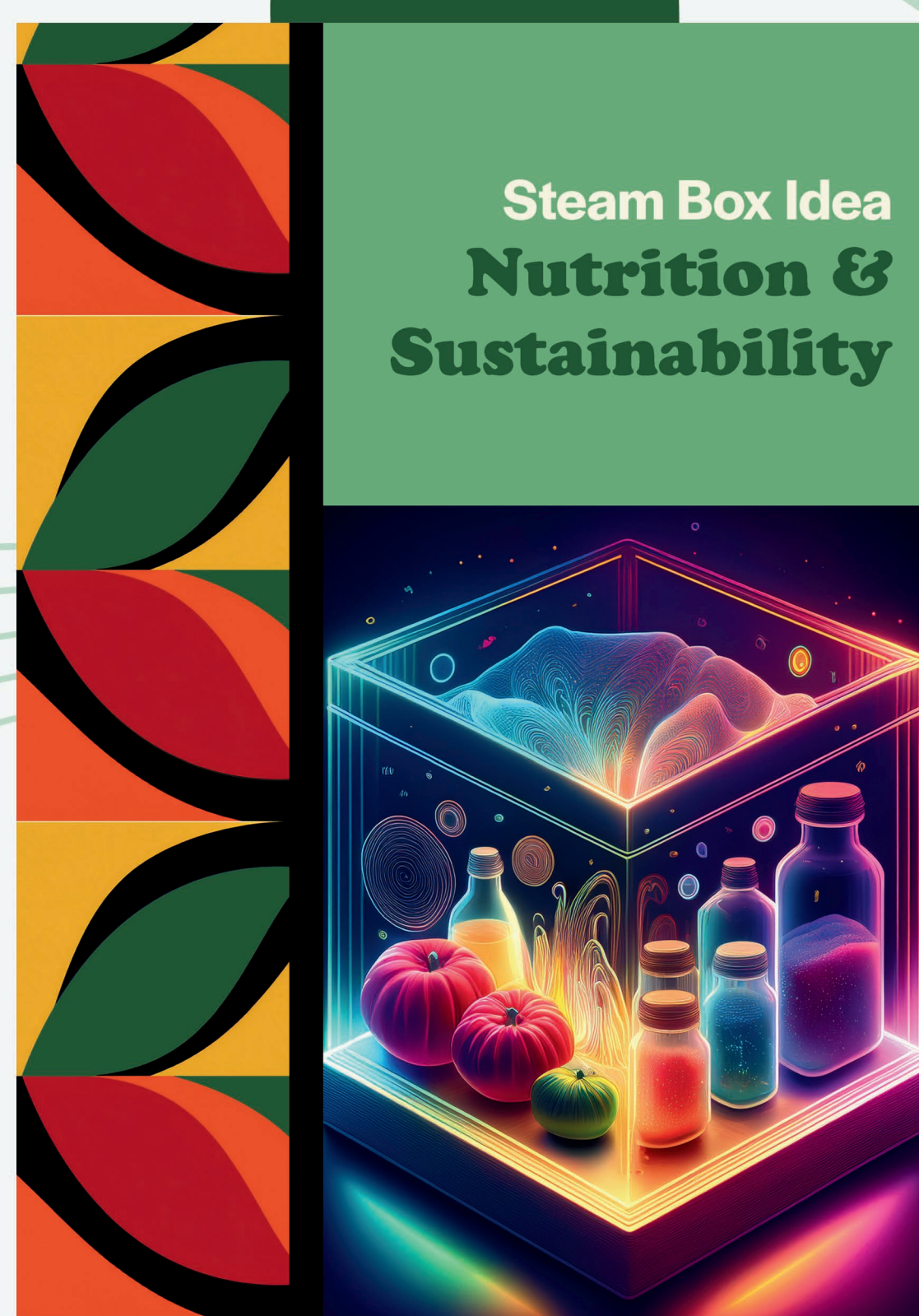
How It Works (The Logic)

- 1. Input:** Sensors stream pH and Humidity data to the central hub.
- 2. Processing:** **Intelligent Software Agents** compare data against safety thresholds (e.g., “Safe Zone: pH 3.0–4.6”).
- 3. Output:** The dashboard hides raw graphs and generates Action Cards.

The Technical Architecture. The system operates on a local network. The **Sorting Agent** and **Consensus Agent** run on the facilitator's tablet.

Teacher Workflow: Guiding vs. Mirroring. The dashboard does not just “mirror” data (displaying raw graphs, which increases load). Instead, it acts as a “**Guiding**” tool, processing student data to issue specific pedagogical instructions.

Just-in-Time Support. Alerts allow the volunteer to act as a “**Wandering Facilitator**,” intervening only when the system flags a risk.



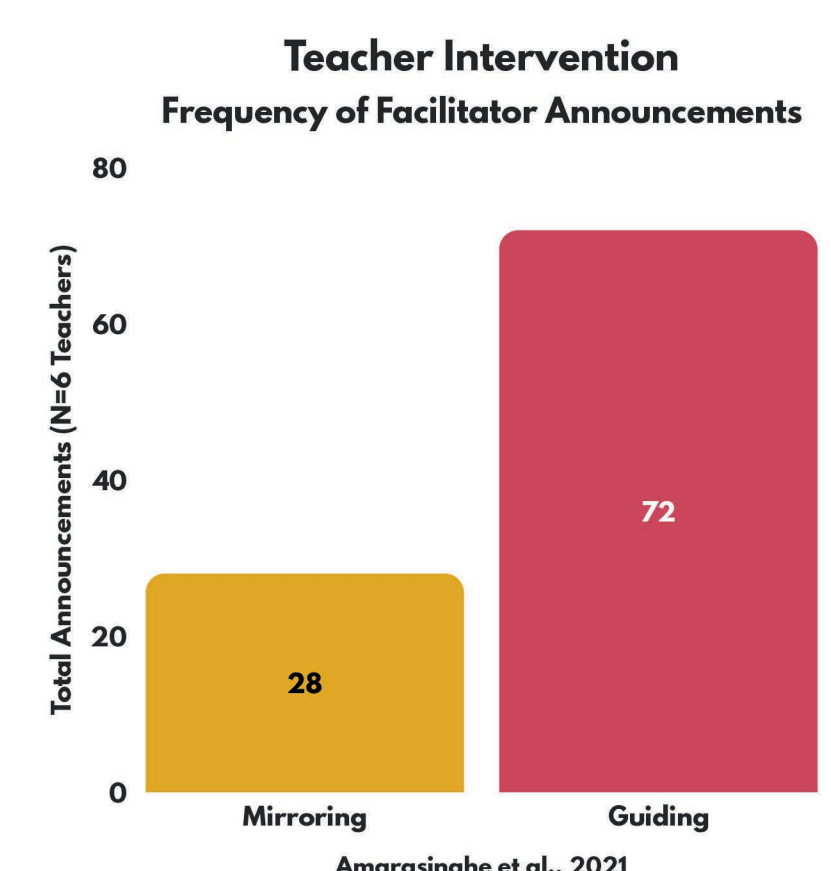
The Theory

Concept Focus: Classroom Usability (π_3)
Third Circle of Usability (π_3): Usability at the whole class level. Standard UX usually focuses on individuals (π_1), this design focuses on how teachers orchestrates the class.

Core Mechanism: Social Plane Transitions
Dashboard reduces friction of moving learners from Experimentation (π_2) to Connection (π_3) and teacher efforts from monitoring to mentoring.

Based in Research

- **Prieto et al. (2018):** Established that “**class-wide orchestration**” induces high cognitive load. Design Application: Centralize monitoring onto single tablet to reduce load.
- **Amarasinghe et al. (2021):** Showed that “**Guiding**” support leads to significantly more effective teacher interventions (see chart).
- **Tissenbaum & Slotta (2019):** Demonstrated that real-time **alerts** allow teachers to intervene only where needed.



The Instrument

Hardware Specifications (The Kit)

- **The Vessel:** 1L Wide-Mouth **Mason Jars** modified with 3D-printed lids housing air locks and sensor ports.
- **The Brain:** **BBC Micro:bit V2** micro controllers, selected for durability and low cost.
- **The Sensors:**
 - **DHT11 Sensor:** Monitors internal humidity and temperature to prevent mold growth.
 - **Analog pH Probe:** Tracks acidity levels (critical safety metric: pH < 4.6).
- **Connectivity:** Sensors transmit data via Bluetooth central tablet.

Software Ecosystem

- **Student Interface:** **Micro:bit MakeCode** (block-based coding) to calibrate sensors and visualize data (histograms).
- **Facilitator Interface:** Custom “**Guiding Dashboard**” web-app (React/Node.js) to aggregate sensor streams.
- **Creative Output:** **Adobe Express** for digital storytelling and **Canva** for the “Living Cookbook” design and “publication” of findings.