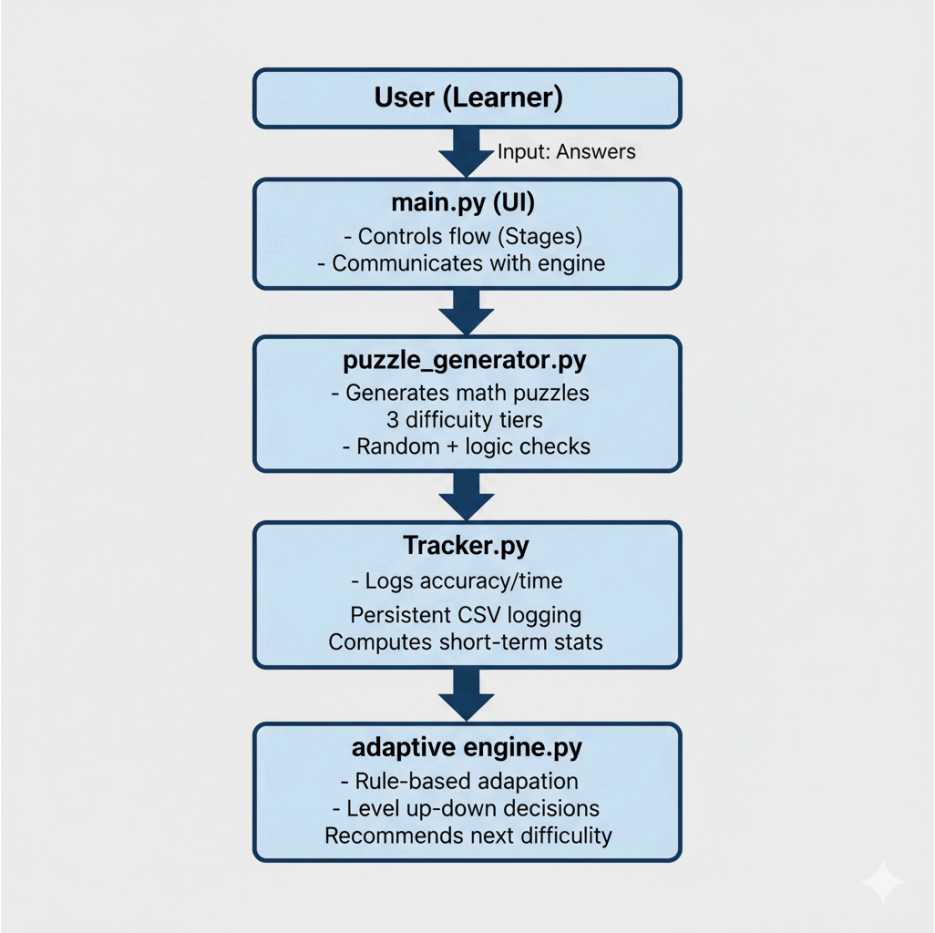
Short Technical Note:

1. System Architecture Overview

Architecture / Flow Diagram



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2. Adaptive Logic Explanation

The adaptive mechanism is **rule-based**. There are 3 difficulty Modes ("Easy", "Difficult", "Hard"), Each Mode has 3 hidden levels that control the problem complexity:

Mode	Problem Types Included
Easy	Addition and Subtraction

Medium	Addition, Subtraction, and Multiplication
Difficult	Addition, Subtraction, Multiplication, and Division

Easy Mode Level Progression (Variable Range):

- **Level 1:** Variables range from 1 to 10 (e.g., 2+3, 8-7).
- **Level 2:** Variables range from 10 to 50 (e.g., 12+34, 48-25).
- **Level 3:** Variables range from 10 to 100 (e.g., 77-27, 89+35).

Level Advancement Criteria:

Level evaluation occurs after every 3 problems, starting from Level 1. To clear a level, two conditions must be met for the 3 preceding problems:

1. **Correctness:** All answers must be correct.
2. **Speed (Average Time to Solve):**
    - **Level 1 Clearance:** Average time must be less than 5 seconds (< 5 sec).
    - **Level 2 Clearance:** Average time must be less than 10 seconds (< 10 sec).
    - **Level 3 is the last level**

Core Logic:

- **Short-term evaluation:** Every 3 attempts, the system computes:
  `accuracy` → percentage of correct responses
  `avg_time` → mean response time

- **Level Up Rule (`should_level_up`)**
  - If all 3 recent answers are correct **and** average time is below a mode-specific threshold (e.g., 5–15 seconds), the level increases.

- **Level Down Rule (`should_level_down`)**
  - If 2 or more of the last 3 answers are incorrect, the level decreases to reinforce fundamentals.

- **Difficulty Recommendation (`recommend_next_difficulty`)**
  - After 15 questions, overall performance is analyzed.
  - Combines both **accuracy** and **speed** to suggest the next difficulty (Easy → Medium → Hard).

This rule-based approach mimics **real-time feedback loops** used in intelligent tutoring systems — simple, explainable, and computationally efficient.

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3. Key Metrics Tracked

Metric	Description	Used For
`correct`	Boolean per attempt (True/False)	Accuracy computation
`time_taken`	Time (in seconds) to answer	Speed evaluation
`avg_time`	Average time per last 3 attempts	Adaptive threshold comparison
`accuracy`	% correct overall	Difficulty recommendation
`level`	Sub-stage within difficulty	Progressive challenge
`event`	Attempt metadata (attempt/skip)	Behavior tracking and logging

The **PerformanceTracker** persistently logs all interactions in a CSV file with timestamps, player info, and outcomes — enabling long-term analytics on learner progress.

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4. Influence of Metrics on Difficulty

Condition	Result	Rationale
High accuracy + fast responses	Level up / Harder questions	Learner is mastering content
Low accuracy + slow responses	Level down / Easier questions	Prevents frustration and maintains motivation
Medium accuracy + average speed	Maintain current level	Balanced performance
End-of-session summary	Suggests next difficulty mode	Personalized next-step recommendation

The thresholds are mode-specific and tuned for progression pacing — ensuring learners neither stagnate nor feel overwhelmed.

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5. Reason for Approach

The **rule-based adaptive system** was chosen over machine learning because:

- **Transparency:** Educators and developers can clearly understand why difficulty changes.
- **Low data dependency:** Works immediately without requiring large training datasets.
- **Real-time responsiveness:** Adaptation occurs instantly based on current performance.
- **Extendability:** Rules can be easily modified to introduce personalized traits or domain-specific patterns.

An ML model could be implemented using the system's saved log data from this system. However, for the present, a rule-based system was chosen over an ML system primarily due to the simpler implementation and the current lack of sufficient real data.

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Note: This content has been partly written, generated and refined using AI to ensure a professional and structured tone and not for any other reasons.