

# User Categorization System & Decision Tree Workflow:(Personalisation Stack)

## Decision Tree Architecture

### Hierarchical CART-Based System

The system uses **three separate CART (Classification and Regression Trees)** arranged hierarchically, with adjustable thresholds and business rule constraints.

## Tree 1: Primary Classification Tree

**Purpose:** Classify users into main categories (1-7 above)

### Input Features:

- objective\_scores.<topic> (continuous)
  - Take learning objectives from sme team
  - Make diagnostic test those objectives
  - Test continuously as each question in a quiz is tagged with an objective
- confidence\_score.<topic> (continuous)
- skills[related] (continuous)
  - Take skill from sme team
  - Make diagnostic test those skills
  - Test continuously as each question in a quiz is tagged with a skill
- confidence\_score\_trends (continuous)

confidence\_score\_trend = average(confidence\_score[t\_i] - confidence\_score[t\_{i-1}] for last N topics)

- Store the increase or decrease from the previous topic confidence scores
- Flagged\_topics from user's side.
- learner\_level (categorical: basic, intermediate, advanced)
  - Thresholds will change acc to this, part of confidence\_score formulas too
- learner\_purpose (categorical: scratch, exploratory, revising)

**Output:** Primary categories

## Primary User Categories

### 1. Struggling Learner

**Characteristics:** Low objective scores, low confidence, needs foundational support.

**Subcategories:**

- **Foundational Gap:** Low skills + low confidence + low performance.
- **Format Mismatch:** Good skills but struggling with current format.
- **Disengaged Struggling:** Low engagement + poor performance.

**System Response:**

- Automatically assign Foundation or Skill Mini-Modules.
- Adjust content format to match learner's comfort.
- Provide proactive explanations and scaffolded tasks.
- Send motivational prompts for re-engagement.

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### 2. Capable but Uncertain

**Characteristics:** Good skills/performance but low confidence.

**Subcategories:**

- **Skill-Confident Gap:** High skills, low confidence in topic.
- **Performance-Confidence Gap:** Good scores but self-doubt.

**System Response:**

- Offer confidence-building messages after correct answers.
- Recommend reflective activities or success journaling.
- Minimize unnecessary hints to build independent thinking.

### **3. Engaged High Performer**

**Characteristics:** High scores, high confidence, high engagement.

**Subcategories:**

- **Challenge Seeker:** Ready for advanced content.
- **Consistent Performer:** Steady progress, needs maintenance.

**System Response:**

- Surface advanced topics and optional challenges.
- Offer mastery badges and leaderboards.
- Provide spaced review to maintain skills.

### **4. Exploratory Learner**

**Characteristics:** High path deviation, varied engagement patterns.

**Subcategories:**

- **Curious Explorer:** High deviation + low hints (self-directed).
- **Lost Explorer:** High deviation + struggling performance.

**System Response:**

- For Curious Explorers: Recommend related topics and optional paths.
- For Lost Explorers: Gently suggest a structured path or foundational review.
- Provide a course map and progress overview.

## 5. Format-Dependent Learner

**Characteristics:** Strong format preferences affecting performance.

**Subcategories:**

- **Visual Learner:** High visual engagement, low text engagement.
- **Microlearner:** Short attention span, prefers chunked content.
- **Conversational Learner:** Prefers informal, friendly explanations.

**System Response:**

- Adapt content delivery to preferred formats.
- Break lessons into smaller segments for microlearners.
- Adjust chatbot/AI tone to match preferred interaction style.

## 6. Declining Performer

**Characteristics:** Negative performance trends, potential fatigue.

**Subcategories:**

- **Fatigued Learner:** Recent score decline + high session time.
- **Overwhelmed Learner:** High hint usage + declining scores.

**System Response:**

- Suggest breaks and wind-down activities.
- Simplify upcoming tasks temporarily.
- Monitor for performance rebound before reintroducing complexity.

## 7. Passive Learner

**Characteristics:** Moderate to good performance but low engagement and minimal interaction beyond required tasks.

**Subcategories:**

- **Passive Completer:** Finishes tasks but avoids extra content or activities.

- **Low-Activity Monitor:** Long gaps between sessions, minimal platform interaction.

#### **System Response:**

- Gentle engagement nudges (“Try an optional challenge today.”).
- Light gamification (badges, streaks).
- Encourage reflection on learning goals.
- No forced interventions unless performance drops.

#### **Adjustable Thresholds:**

```
tree1_thresholds = {
    'objective_score_struggling': 0.6, # Adjust per learner level if needed
    'confidence_score_uncertain': 0.5,
    'skills_proficiency_low': 0.4, # Adjust dynamically
    'score_trend_declining': -0.1,
    'path_deviation_exploratory': 0.3,
    'hint_ratio_overwhelmed': 0.3,
    'engagement_score_low': 0.8,
    # learner_level used for adaptive adjustment
}
```

## **Tree 2: Intervention Type Tree**

**Purpose:** Determine specific intervention needed for pre-requisites, pacing, and support level

**Input Features:**

- session\_preference (categorical: short\_chunks, long\_sessions)
  - attention\_span (continuous)
- format\_preference (categorical: video, image, text)
  - Only text for mvp
- revisiting\_module
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**Output:** Intervention needed (pacing, support level, additional skills/modules)

Types of strategies mapping to interventions:

**Adjustable Thresholds:**

LMW topic

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What topics are you having trouble with? (Optional)

- If user clicks the answer button, it gives them radio button options to choose from.

Module quiz is passed.

MODULE IS COMPLETE!

1 Survey (Compulsary– how confident is a user on the module)

- 4-5 questions
  - Radio button topics they need help with
  - Format preference
  - Confidence in each topic (sliding bar)
  - Overall if there is anything they want to tell us

HOLDING OFF ON TREE 3 TILL FEATURES OF LMW ARE FINALIZED.

### **Tree 3: Content Delivery Tree**

**Purpose:** Determine how to deliver the intervention

**Input Features:**

- intervention\_type (categorical: from Tree 2)
- recent\_interaction\_patterns (continuous)
  - How the user has been using the LMW
    - Which LMW elements are being used?
    - How much time is spent on each element?
- previous\_intervention\_success (continuous)
- time\_since\_last\_interaction (continuous)
- cumulative\_session\_time (continuous)

**Output:** Specific delivery method

Continuous Learning

- 1. Feedback Loop: Collect user responses to interventions
- 2. Model Updates: Retrain monthly with new interaction data
- 3. Rule Refinement: Update business rules based on model insights
- 4. A/B Testing: Test new intervention strategies systematically

Decision Tree Architecture

Decision Tree 1:

ID	Profile Name	Aggregated Rule	LLM Prompt Template
P1	Struggling Novice	<code>avg_objective_score &lt; 5.5, avg_confidence_score &lt; 0.4, avg_skill_score &lt; 4.0, confidence_trend &lt; -0.05, learner_level = basic</code>	“Provide beginner-friendly content for {next_topic}. Use simple examples and a motivational tone. Also review these topics with low scores: {redo_topics}.”
P2	Lost Climber	<code>avg_objective_score &lt; 5.5, avg_confidence_score &lt; 0.4, confidence_trend ∈ [-0.05, 0.05],</code>	“Teach {next_topic} gently with scaffolding. Add revision for previous low-score topics {redo_topics}. Reinforce concepts without overwhelming.”



		learner_level = intermediate	
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<b>P3</b>	Overconfident Novice	avg_objective_score < 5.5, avg_confidence_score ≥ 0.6, avg_skill_score < 4.0	“Create corrective content for {next_topic} using misconception targeting. Balance confidence and actual performance. Add soft guidance.”
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<b>P4</b>	Rising Improver	avg_objective_score ∈ [5.5, 6.5], avg_confidence_score ∈ [0.45, 0.6], confidence_trend > 0.05	“Encourage the learner in {next_topic}. Use light challenges, positive feedback, and adaptive questioning. Track flagged topics: {flagged_topics}.”
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<b>P5</b>	Stabilized Climber	avg_objective_score ≥ 6, avg_confidence_score ∈ [0.5, 0.6], avg_skill_score ≥ 4.0, confidence_trend ∈ [-0.05, 0.05]	“Provide standard-paced content for {next_topic}. Offer brief concept checks. Recommend revision of {flagged_topics} in future.”
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<b>P6</b>	Confused Confident	$\text{avg\_objective\_score} < 5.5,$ $\text{avg\_confidence\_score} \geq 0.6,$ $\text{confidence\_trend} < -0.05$	“Help recalibrate confidence by gently reinforcing concepts. Focus on $\{\text{next\_topic}\}$ with layered examples. Watch for misunderstanding.”
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<b>P7</b>	Overreacher	$\text{avg\_objective\_score} \in [5.5, 6.5],$ $\text{avg\_confidence\_score} > 0.7,$ $\text{avg\_skill\_score} < 4.0$	“Design challenging yet clarifying content for $\{\text{next\_topic}\}$ . Use just-in-time hints. Insert review prompts from $\{\text{flagged\_topics}\}$ .”
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<b>P8</b>	Well-Balanced Explorer	$\text{avg\_objective\_score} \in [6, 7.5],$ $\text{avg\_confidence\_score} \geq 0.6,$ $\text{confidence\_trend} > 0.05,$ $\text{learner\_purpose} = \text{exploratory}$	“Deliver content for $\{\text{next\_topic}\}$ that promotes exploration. Include optional deep-dives. No redo needed, but revisit $\{\text{flagged\_topics}\}$ later.”
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<b>P9</b>	Stable Expert	$\text{avg\_objective\_score} \geq 8.0,$ $\text{avg\_confidence\_score} \geq 0.7,$	“Generate concise, expert-level content for $\{\text{next\_topic}\}$ . Focus on advanced application. Skip
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		$\text{avg\_skill\_score} \geq 6.0$ , $\text{learner\_level} = \text{advanced}$	review unless learner marks topics.”
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<b>P10</b>	Repetition-Focused Pro	$\text{avg\_objective\_score} \geq 7.0$ , $\text{avg\_confidence\_score} \geq 0.6$ , $\text{confidence\_trend} \in [-0.05, 0.05]$ , $\text{learner\_purpose} = \text{revising}$	“Summarize key ideas of {next_topic} quickly. Add advanced refreshers for {flagged_topics}. Assume learner is competent.”
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<b>P11</b>	Flagged-Gap Learner	$\geq 2$ topics in $\text{flagged\_topics} \cap \text{previous\_covered\_topics}$	“Focus new content on {next_topic}, but interleave key explanations from {flagged_topics}. Use learner-specified weaknesses as emphasis.”
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<b>P12</b>	Confidence Collapse	$\text{avg\_confidence\_score} < 0.4$ , $\text{confidence\_trend} < -0.1$	“Build emotional safety in {next_topic}. Use confident tone, relatable mistakes, and peer-style feedback. Defer challenges.”
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<b>P13</b>	Fast Tracker	$\text{avg\_objective\_score} \geq 8.0,$ $\text{avg\_confidence\_score} \geq 0.7,$ $\text{confidence\_trend} > 0.05,$ $\text{len}(\text{redo\_topics}) = 0$	“Deliver fast-paced content for {next_topic} with deeper challenges. No review necessary. Acknowledge rapid mastery.”
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<b>P14</b>	Slow But Sure	$\text{avg\_objective\_score} \geq 6.5,$ $\text{confidence\_trend} \in [0.01, 0.05],$ $\text{avg\_confidence\_score} \in [0.5, 0.6]$	“Continue steady progress in {next_topic}. Keep pacing moderate. Reinforce recent mastery lightly.”
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<b>P15</b>	Unaware Gap Learner	$\geq 2$ topics where $\text{objective\_score} < 6$ AND $\text{flagged\_topics} = \emptyset$	“Highlight implicit weaknesses in {redo_topics} while teaching {next_topic}. Use probing questions to surface gaps.”
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<b>P16</b>	Recovery -Oriented	$\text{len}(\text{redo\_topics}) \geq 3,$ $\text{confidence\_trend} > 0.05$	“Alternate between recovery ({redo_topics}) and new ({next_topic}) content. Celebrate progress. Emphasize structure.”
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<b>P17</b>	Confidence-Delayed	<code>avg_objective_score ≥ 7.0,</code> <code>avg_skill_score ≥ 5.5,</code> <code>avg_confidence_score &lt; 0.5</code>	“Encourage self-trust in {next_topic}. Emphasize learner competence. Limit hints to build independent thinking.”
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<b>P18</b>	Confused Explorer	<code>avg_confidence_score ∈ [0.5, 0.7],</code> <code>stddev(objective_score) &gt; 1.5,</code> <code>learner_purpose = exploratory</code>	“Help stabilize learning in {next_topic}. Reduce variability with consistent patterns. Include review of {flagged_topics}.”
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## Decision Tree 2 Architecture



### Comprehensive Decision Table

`revisiting_module = True`

ID	Strategy Label	Conditions	<code>session_structure</code>	<code>next_format</code>	Intervention: in the format of LLM Prompt
<b>R1</b>	<b>Short-Text Bouncer</b>	<code>session_reference =</code> <code>short_chunks</code> AND	<code>short_chunks</code>	<code>text</code>	“Break down module in short text blocks (≤5 min). Emphasize

		attention _span < 10 AND format_pr eference = text			simplicity and repetition.”
<b>R2</b>	<b>Visual Burst Learner</b>	Same as R1 but format_pr eference = image	short_ch unks	image	“Deliver 1-image-per- concept slides or flowcharts per idea.”
<b>R3</b>	<b>Video Refresher</b>	Same as R1 but format_pr eference = video	short_ch unks	video	“Provide 2–3 min videos per topic with transcripts.”
<b>R4</b>	<b>Focused Text Learner</b>	revisitin g_module = True AND session_p reference = long_sess ions AND attention _span ≥ 10 AND	long_ses sions	text	“Deliver entire module in 20–25 min guided text tutorials.”

		format_preference = text			
<b>R5</b>	<b>Visual Concentrator</b>	Same as R4 but format_preference = image	long_sessions	image	“Teach full module using labeled diagrams & conceptual maps.”
<b>R6</b>	<b>Video Explainer</b>	Same as R4 but format_preference = video	long_sessions	video	“Deliver 10–12 min instructional videos with mid-video check questions.”
<b>R7</b>	<b>Mismatch Text Splitter</b>	revisiting_module = True AND session_preference = long_sessions AND attention_span < 10 AND format_pr	short_chunks	text	“Mismatch: Split content into 5–6 min text pieces even though long format is preferred.”

		reference = text			
<b>R8</b>	<b>Mismatch Visual Cutter</b>	Same as R7 but format_pre ference = image	short_ch unks	image	“Split visual concepts into sequential illustrations.”
<b>R9</b>	<b>Mismatch Video Snacker</b>	Same as R7 but format_pre ference = video	short_ch unks	video	“Deliver microlearning video bites with concept labeling.”
<b>R10</b>	<b>Fallback Text Coach</b>	revisitin g_module = True AND borderline cases (attention_s pan ∈ [9,11])	short_ch unks	text	“Split topics into ~7 min text sections with structured guidance.”
<b>R11</b>	<b>Default Remedial Learner</b>	All other revisitin g_module = True cases	short_ch unks	text	“Default fallback: simple, short-text chunks for better understandin g.”



revisiting\_module = False

Cases (Learner Progressing)

ID	Strategy Label	Conditions	session_structure	next_format	LLM Prompt Summary
F1	Chunked Forward Mover	session_preference = short_chunks AND attention_span < 10 AND format_preference = text	short_chunks	text	“Continue with next module in short, focused text blocks. Emphasize key takeaways.”
F2	Visual Navigator	Same as F1 but format_preference = visual	short_chunks	image	“Use simple diagrams, illustrations per subtopic. Don’t repeat old material.”
F3	Video Streamline Learner	Same as F1 but format_preference = videos	short_chunks	video	“Deliver next module in 2–4 min videos per concept. Avoid repetition.”
F4	Text Mastery Learner	revisiting_module = False AND session_preference = long_sessions AND attention_span ≥ 10 AND	long_sessions	text	“Deliver module as in-depth textual explanations with summaries.”

		<code>format_preference = text</code>			
<b>F5</b>	<b>Visual Immersionist</b>	Same as F4 but <code>format_preference = visual</code>	<code>long_sessions</code>	<code>image</code>	“Use concept maps and complete visual walkthroughs for new content.”
<b>F6</b>	<b>Video Focused Learner</b>	Same as F4 but <code>format_preference = videos</code>	<code>long_sessions</code>	<code>video</code>	“Long-format instructional videos for new content. Mid-video Q&A checkpoints.”
<b>F7</b>	<b>Mismatch Text Forwarder</b>	<code>revisiting_module = False</code> AND <code>session_preference = long_sessions</code> AND <code>attention_span &lt; 10</code> AND <code>format_preference = text</code>	<code>short_chunks</code>	<code>text</code>	“Break forward content into shorter blocks to match learner attention.”
<b>F8</b>	<b>Mismatch Visual Forwarder</b>	Same as F7 but <code>format_preference = image</code>	<code>short_chunks</code>	<code>image</code>	“Slice diagrams by concept and arrange sequentially.”
<b>F9</b>	<b>Mismatch Video Forwarder</b>	Same as F7 but <code>format_preference = video</code>	<code>short_chunks</code>	<code>video</code>	“Convert forward module into small standalone videos.”

F10	Forward Text Balance	Attention_span = 9 mins	short_chunks	text	“Deliver next module in hybrid text chunks (7–9 mins). Add reflection points.”
F11	Default Forward Learner	All other progressing cases	short_chunks	text	“Safe delivery: next module in short text blocks for consistent pacing.”