

# **DTI INTEGRATION**

## **Cognitive Load Estimator for Online Learning**

### **TEAM-19**

**1.Team Name:** Group 19

**Team Members:**

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## **2. Problem/Opportunity Domain**

**Domain of Interest:**

**Online Learning and Educational Technology**

**Focus Area:**

**Cognitive Load Estimation for Adaptive E-Learning Systems**

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**Description:**

**In online learning environments, students often experience uneven cognitive load — either too high (overload and frustration) or too low (boredom and disengagement). Current e-learning platforms lack real-time awareness of a learner’s mental effort, making it difficult to adjust teaching pace or difficulty dynamically.**

**This project proposes an AI-powered Cognitive Load Estimator using behavioral and physiological indicators (such as response time, quiz performance, and interaction patterns). Using machine learning and AIML-based conversational feedback, the system monitors cognitive load in real-time and offers adaptive learning recommendations, improving engagement and retention.**

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#### **Why Chosen:**

- **Online learners struggle with self-paced learning and lack personalized guidance.**
  - **Teachers need a way to monitor engagement remotely and intervene effectively.**
  - **Reduces dropout rates by detecting cognitive overload early and improving motivation.**
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#### **Aligns with Sustainable Development Goals (SDGs):**

- **SDG 4 – Quality Education: Promotes personalized and inclusive learning for all.**
- **SDG 9 – Industry, Innovation, and Infrastructure: Encourages the use of AI and data-driven insights in education technology.**

- **SDG 10 – Reduced Inequalities: Provides adaptive support for diverse learners, regardless of background or ability.**
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#### **Alternatives & Limitations:**

| <b>Existing Method</b>             | <b>Limitations</b>  |
|------------------------------------|---|
| <b>Static E-learning Platforms</b> | <b>No personalization or adaptive difficulty</b>                |
| <b>Manual Teacher Monitoring</b>   | <b>Not scalable in large online classes</b>                     |
| <b>Fixed Difficulty Quizzes</b>    | <b>Cannot adjust to individual learner's cognitive capacity</b> |

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#### **Customers:**

- **Students in online learning platforms**
  - **Educational institutions adopting e-learning**
  - **Corporate training programs**
  - **Teachers and learning facilitators seeking adaptive teaching tools**
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#### **Emotional Impact:**

Students often feel frustrated or anxious when content feels too hard and disengaged when it feels too easy. The inability to track mental effort leads to demotivation and low self-efficacy.

**Quantifiable Impact:**

- Up to 35% improvement in engagement through adaptive pacing
  - Reduced dropout rate by detecting overload early
  - Higher learning retention through personalized cognitive balancing
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**Alternative Shortcomings:**

- No real-time mental effort tracking
- No adaptive content adjustment
- No emotional or behavioral feedback loop

**3. Addressing SDGs (Sustainable Development Goals)**

| Relevant SDG              | Contribution   |
|---------------------------|--|
| Goal 4: Quality Education | Promotes personalized, adaptive, and inclusive e-learning systems. |

**Goal 9: Industry, Innovation, and Infrastructure**      **Integrates AI and ML for smart, data-driven learning platforms.**

**Goal 10: Reduced Inequalities**      **Ensures equal learning opportunities for students with different cognitive abilities.**

## 4. Stakeholders

- **Students / Learners**
- **Teachers / Educators**
- **E-Learning Platform Developers**
- **Educational Institutions**
- **Psychologists / Cognitive Scientists**
- **Parents and Mentors**

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### Power–Interest Matrix of Stakeholders:

| Category                  | Stakeholder Examples     | Engagement Strategy                             |
|---------------------------|--------------------------|---|
| High Power, High Interest | Educators, Psychologists | Involve in model validation and feature testing |

|                                 |                                     |   |
|---------------------------------|-------------------------------------|---|
| <b>High Interest, Low Power</b> | <b>Students</b>                     | <b>Prioritize usability and motivation</b>                  |
| <b>Low Interest, High Power</b> | <b>Administrators, Institutions</b> | <b>Highlight cost-effectiveness and performance reports</b> |
| <b>Low Power, Low Interest</b>  | <b>General public</b>               | <b>Awareness through pilot results and case studies</b>     |

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## **Empathetic Interviews**

| <b>I Need to Know</b>                                    | <b>Questions I Will Ask</b>  | <b>Insights I Hope to Gain</b>                                   |
|--|--|--|
| <b>How do students feel during difficult lessons?</b>    | <b>What makes online learning stressful or tiring?</b>                 | <b>Understand triggers of high cognitive load.</b>               |
| <b>How do teachers assess student engagement online?</b> | <b>What signs help identify when students are overloaded or bored?</b> | <b>Learn which cues are most valuable for adaptive response.</b> |
| <b>What kind of feedback motivates learners?</b>         | <b>Do students prefer hints, breaks, or simplified explanations?</b>   | <b>Discover effective intervention strategies.</b>               |
| <b>How comfortable are users with AI monitoring?</b>     | <b>Would you be okay with AI analyzing your learning behavior?</b>     | <b>Understand privacy comfort and trust factors.</b>             |

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## Skilled Interview Report

| User/Interviewee   | Questions Asked   | Insights Gained (NOT Their Answers)  |
|--------------------|---|--|
| Srivarsha, Student | How does the system detect cognitive load from online activity? | Uses metrics like response time, quiz accuracy, click rate, and task duration to estimate mental effort. |
| Devansh, Brother   | What are challenges in collecting accurate data?                | Variations in attention span, mood, and environment require normalization and robust modeling.           |
| Vijaya, Sister     | How does the system help new users with no history?             | Baseline cognitive profile built using short calibration sessions.                                       |
| Puneeth, Friend    | Will it adapt to changes in a student's progress?               | Yes, uses continuous learning to adjust load predictions and difficulty levels.                          |
| Pradeepa, Friend   | What metrics evaluate accuracy?                                 | Uses precision, recall, RMSE (error in load prediction), and user satisfaction.                          |

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## 7. Empathy Map

### a. Who is your Customer?

Students and teachers using online learning platforms.

### b. Who are we empathizing with?

Learners struggling to maintain focus and comprehension during online lessons.

**Key Points:**

- They want timely help when overloaded.
  - They seek visible progress feedback.
  - They fear being judged by AI.
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## 8. Persona of Stakeholders

**Stakeholder Name:** Anjali, 20

**Demographics:** College student, uses online classes daily.

**Goals:** Learn efficiently and retain knowledge with minimal fatigue.

**Challenges:** Feels lost during fast-paced lessons; hard to self-regulate learning pace.

**Aspirations:** Improve study habits and focus.

**Needs:** Real-time feedback on mental effort.

**Pain Points:** No feedback on when to take breaks or slow down.

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## 9. Look for Common Themes, Behaviors, Needs, and Pain Points

**Common Themes:** Desire for personalized learning and motivation.

**Common Behaviors:** Long screen hours, inconsistent focus, multitasking.

**Common Needs:** Adaptive pacing, clarity, engagement.

**Common Pain Points:** Overload, boredom, and lack of real-time feedback.

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## 10. Define Needs and Insights of Your Users

**User Needs:**



- **Real-time detection of cognitive load**
- **Personalized feedback and pacing**
- **Simple, visual progress tracking**
- **Data privacy and transparency**

#### **User Insights:**

- **Students overestimate their understanding under stress.**
- **Most learners fail to take breaks when cognitively overloaded.**
- **Teachers need visual indicators to monitor class attention.**
- **Users trust systems that explain decisions clearly.**

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## **13. POV Statements**

| <b>PoV Statement</b>  | <b>PoV Question</b>   |
|---|---|
| <b>Students need real-time awareness of their cognitive load to manage learning stress effectively.</b> | <b>How might we help learners monitor and balance their cognitive load in real time?</b>    |
| <b>Teachers need insights into student mental effort to adapt teaching pace.</b>                        | <b>How might we provide teachers with intuitive dashboards showing learner load trends?</b> |

**Learners fear being judged by AI systems.      How might we design transparent, privacy-safe feedback that builds trust?**

**Students lose focus in monotonous lessons.      How might we increase engagement through adaptive, motivational responses?**

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## **14. “How Might We” (HMW) Questions**

| <b>User Need/Insight</b>                                 | <b>HMW Question</b>  |
|--|--|
| <b>Students need feedback when overloaded.</b>           | <b>How might we give real-time, friendly alerts when cognitive load is high?</b>     |
| <b>Teachers need to track class engagement remotely.</b> | <b>How might we visualize collective cognitive load trends for teachers?</b>         |
| <b>Learners want privacy.</b>                            | <b>How might we estimate cognitive load without capturing sensitive visual data?</b> |
| <b>Students prefer motivation over warnings.</b>         | <b>How might we turn cognitive feedback into encouraging messages?</b>               |

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## **16. Design Challenge Statement**

### **Design Challenge:**

**Design a real-time, privacy-conscious, and adaptive Cognitive Load Estimator that monitors student performance, predicts mental effort using AI, and delivers**

personalized feedback through conversational support to enhance engagement and learning efficiency.

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## 17. Validation Plan

**Objective:**  
Ensure the Cognitive Load Estimator is accurate, trustworthy, and user-friendly.

| Stakeholder/Use<br>r | Role            | Feedback on Problem<br>Statement               | Suggestions                                 |
|----------------------|-----------------|--|---|
| Students             | End<br>Users    | Found helpful for pacing<br>studies.           | Add visual cues and<br>relaxation prompts.  |
| Teachers             | Instructo<br>rs | Useful for identifying<br>struggling students. | Include class summaries of<br>average load. |
| Developers           | Engineer<br>s   | System design feasible<br>using ML models.     | Optimize model for<br>real-time execution.  |

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## 18. Ideation

| Idea<br>No. | Proposed Solution                    | Key Features/Benefits   | Challenges/Concerns                 |
|-------------|--------------------------------------|---|-------------------------------------|
| 1           | ML-based Cognitive<br>Load Detection | Real-time estimation via quiz<br>time, accuracy, and<br>interaction | Accuracy under varied<br>conditions |

|   |                                       |   |                                      |
|---|---------------------------------------|---|--------------------------------------|
| 2 | <b>Adaptive Lesson Recommendation</b> | <b>Adjusts difficulty and pace</b>        | <b>Requires continuous data</b>      |
| 3 | <b>AIML Conversational Support</b>    | <b>Motivates users during high load</b>   | <b>Designing natural responses</b>   |
| 4 | <b>Teacher Dashboard</b>              | <b>Displays student engagement trends</b> | <b>Data visualization complexity</b> |
| 5 | <b>Privacy-First Architecture</b>     | <b>Uses anonymized metrics</b>            | <b>Ensuring data security</b>        |

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## **Solution Concept Form – Cognitive Load Estimator for Online Learning**

### **1. Problem Statement:**

**Students in online learning environments often face inconsistent engagement due to unmanaged cognitive load. Current systems lack real-time mechanisms to detect and balance mental effort.**





