

OwLLM: A Learning Management System Prototype with LLM-Assisted Course Interaction

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An Honors Thesis Submitted to the Department of Computer Science and the Honors College

Thesis Committee: Dr Imad Antonios, Dr Winnie Yu, and Professor Paul Mckee

Project Idea

- Origins

- Adaptation

- Context and Relevance

"Programming the Future of Education"

FUTURE IMPLICATIONS

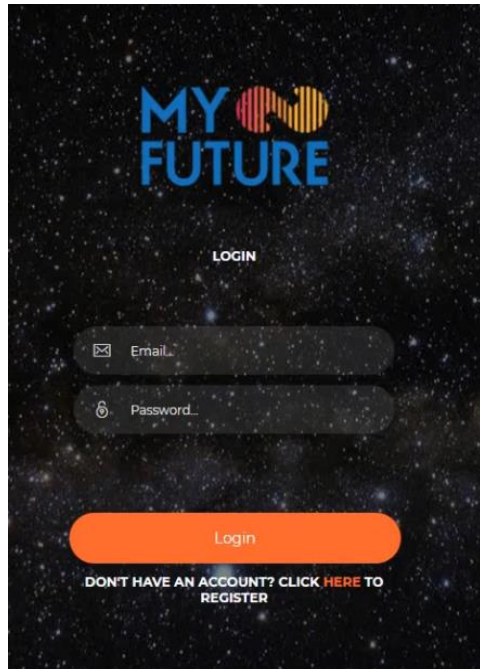
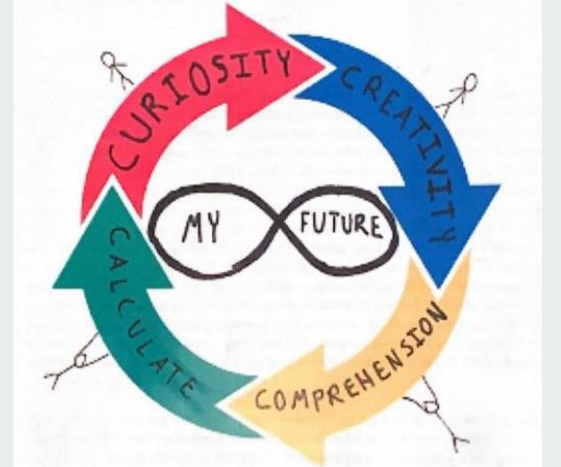
- University Plans
 - Honors Program
 - Capstone program
 - Senior thesis
- Website phases/features
 - Algorithms (grading, recommendations, progress tracker)
 - C Cycle Fuel System
- Goal: Improve Education → Change World



CAPSTONE

"Programming the future of education"

- Class Idea Proposal
- Website Application

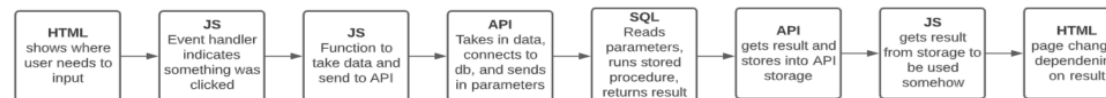


LEARNING STRETCH & TAKEAWAYS

- New programming languages and concepts
 - Front End/Client Side
 - HTML, CSS, JavaScript - languages
 - Backend/Server Side
 - SQL - database language
 - Entity-Relationship Diagrams - structure and flow
 - Stored Procedures - input/output database
 - Application Programming Interface (API)
 - C# - coding language
 - ASP. Net MVC - architecture framework
 - JSON - data formatting
 - Other
 - Pagination - way to track progress
 - Concatenation - simplify input/output to database
 - SurveyJS - fully customizable content for quizzes/topics
 - Debugging tricks

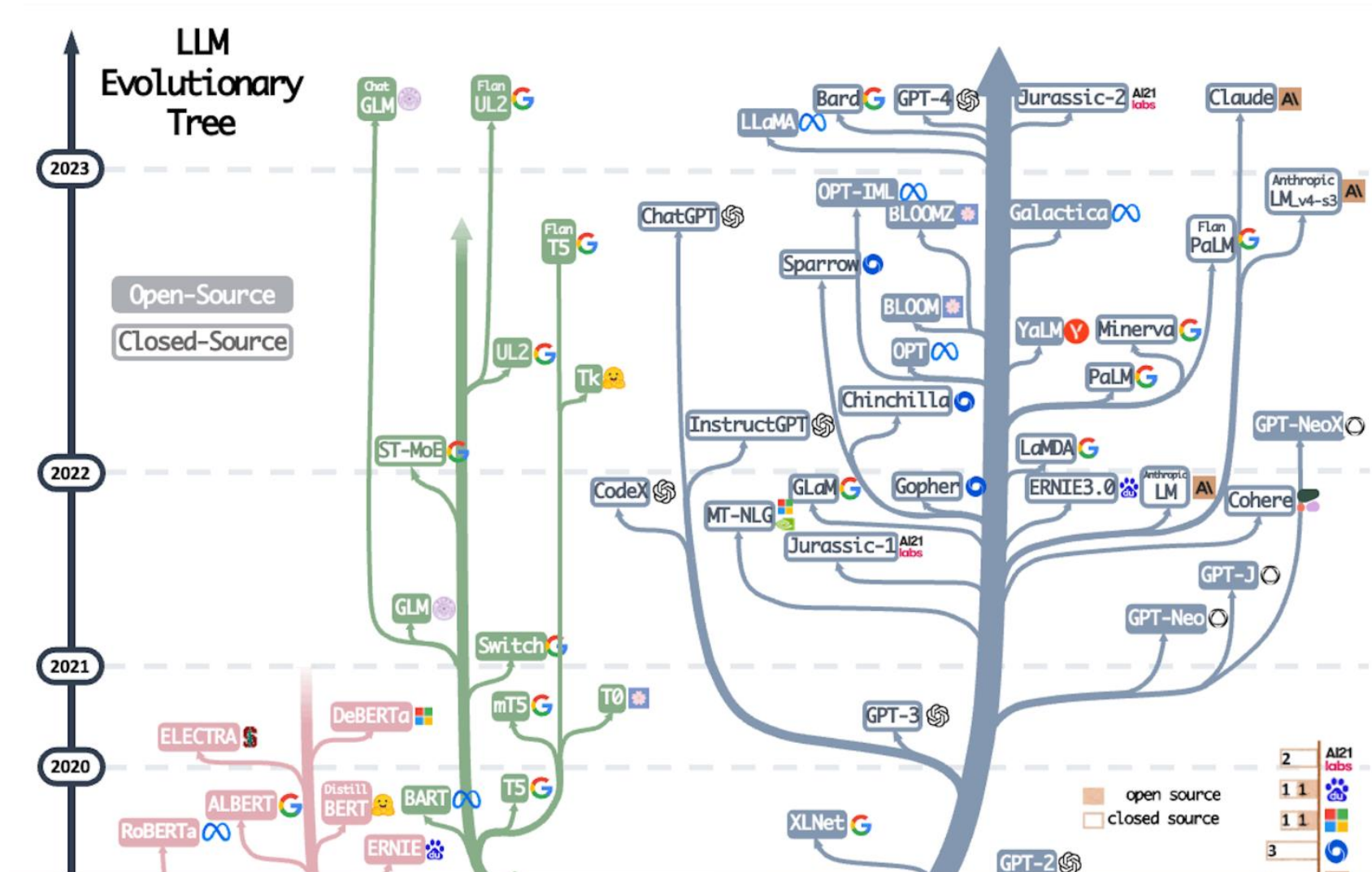


Main Process Takeaway



Project Idea: Origins, Adaptation Context and Relevance

Evolution and Integration of LLM Technology



Project Idea: Origins, Adaptation Context and Relevance

Computer Science and Honors College

Degree progress



Requirements Credits

 Minimum Credits - Computer Science (General) **Still needed:** 52 credits are required. You currently have 49, you still need 3 more credits.

 6-Credit Capstone Requirements

 Departmental Honors Prospectus/Thesis	HON 494	~CSC Honors Prospectus	A-
	HON 495	~CSC Departmental Honors	IP

Project Idea: Origins, Adaptation, Context and Relevance

Southern Connecticut State University a Social Justice, Liberal Arts, DEI Institution



Project Idea: Origins, Adaptation, Context and Relevance

Literature Review

- Scope

- Coverage

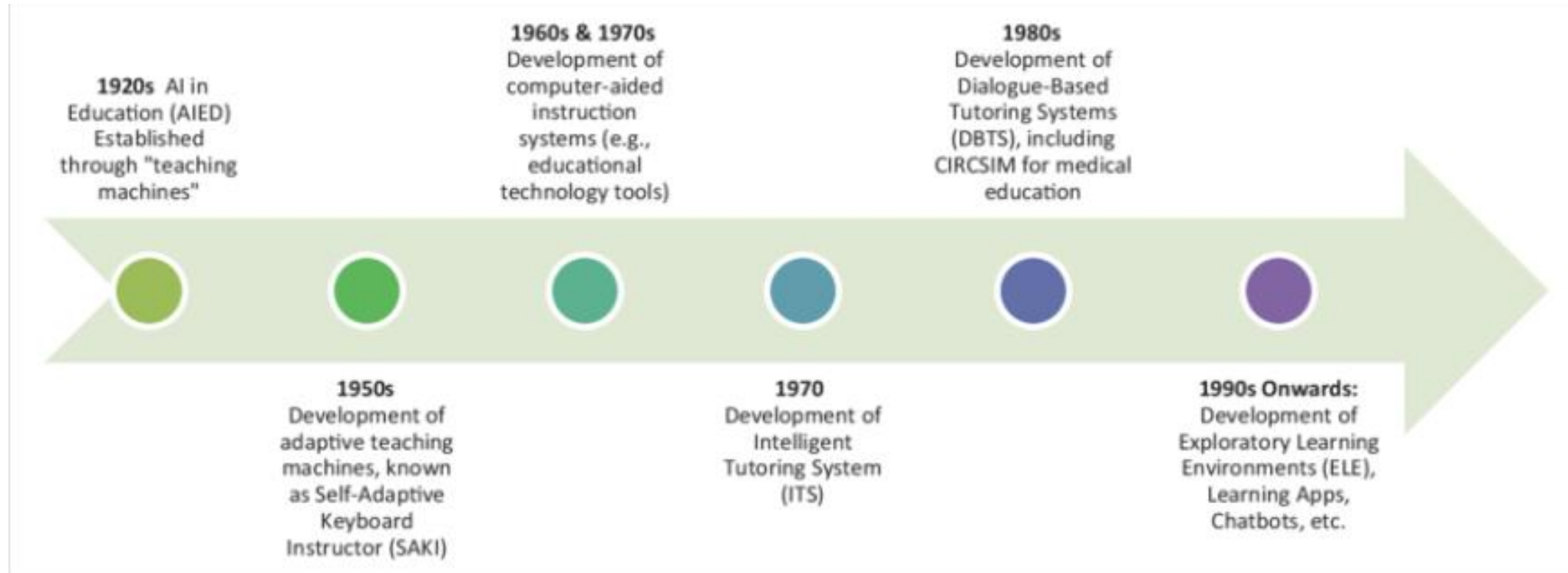
AI in Education: An Overview



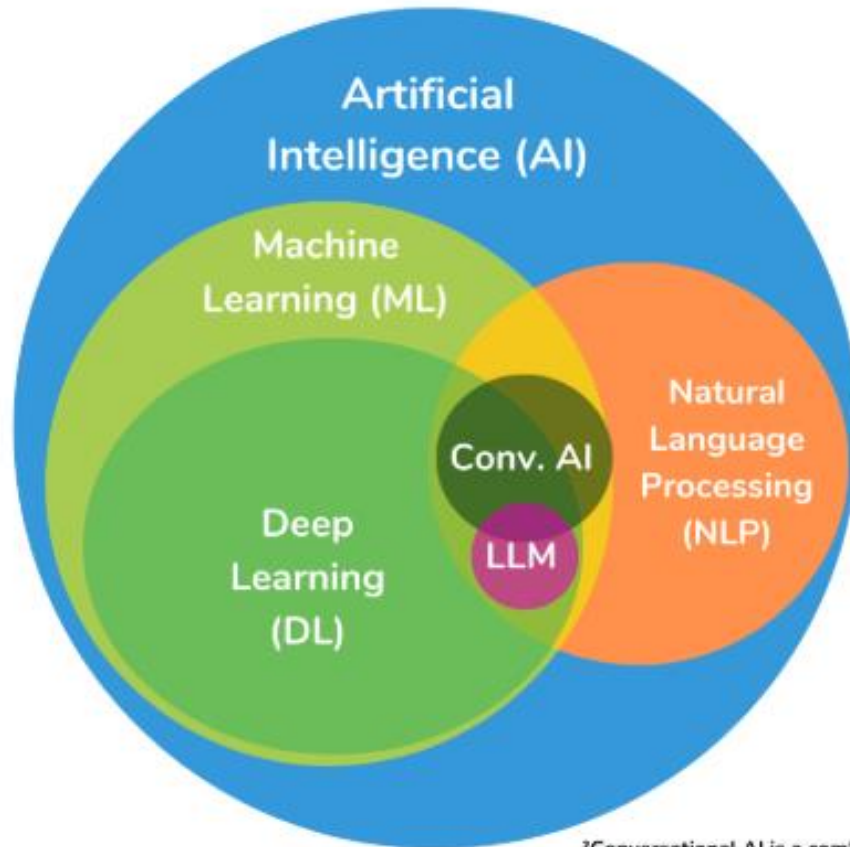
“AI as a Catalyst for Inclusive, Personalized, and Ethical Education: Empowering Teachers and Students for an Equitable Future”

Literature Review: Scope and

AI in Education: An Overview



Distinguishing AI, Machine Learning, NLP, and LLM

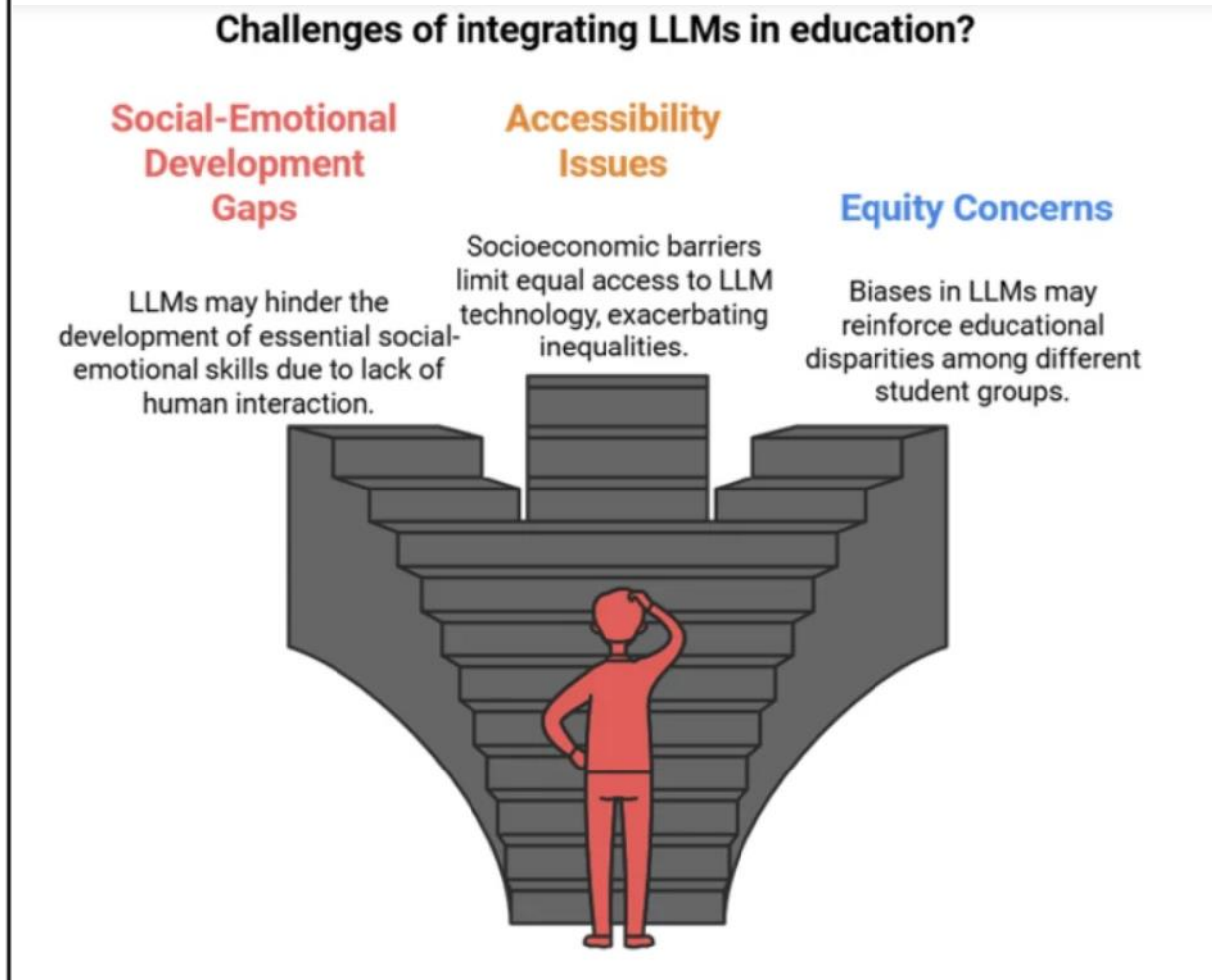
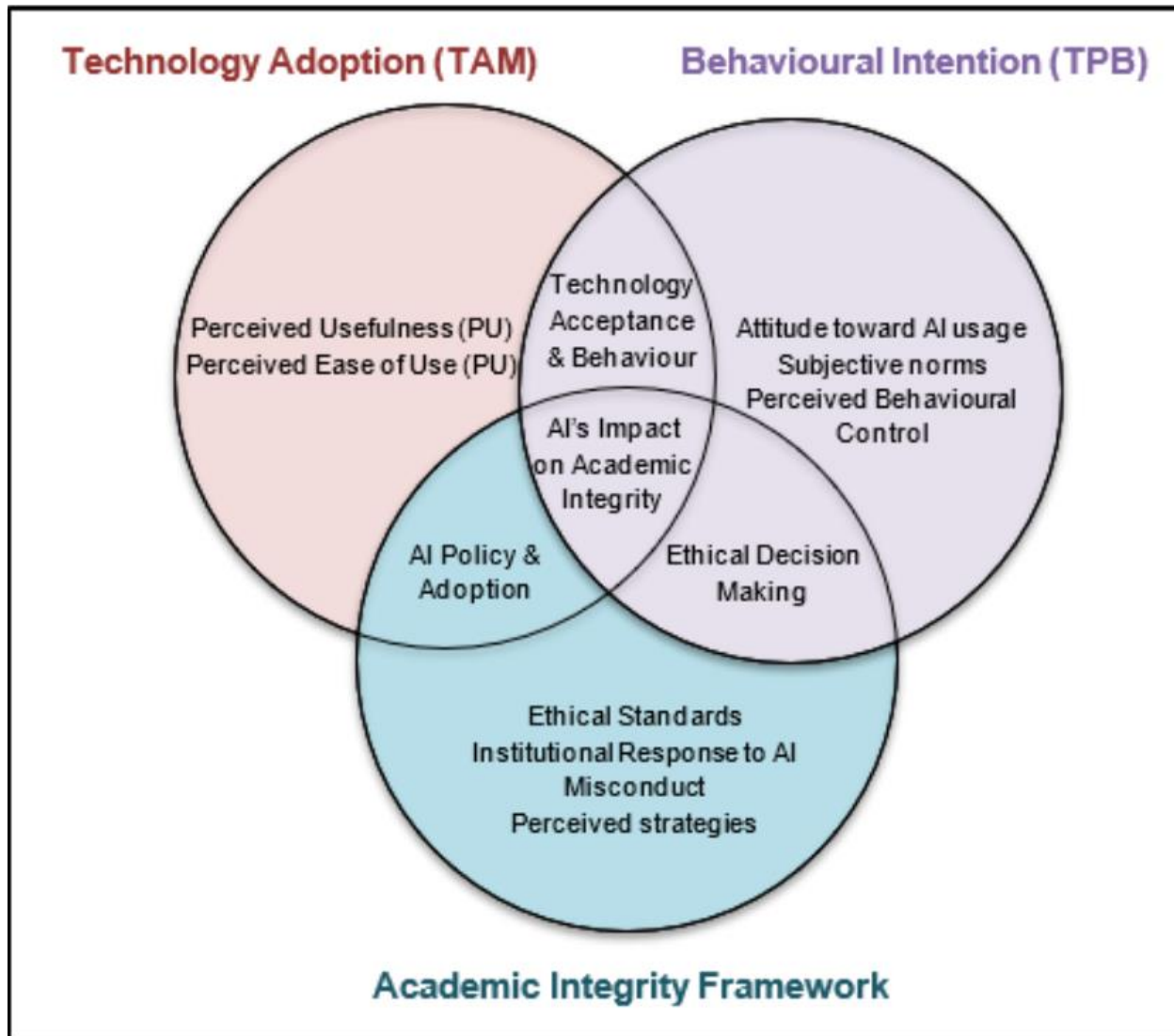


- Artificial Intelligence (AI)
- Machine Learning (ML)
- Deep Learning (DL)
- Natural Language Processing (NLP)
- Large Language Model (LLM)¹
- Conversational AI (Conv. AI)²

¹LLM is an intersection of DL and NLP

²Conversational AI is a combination of ML and NLP. It may include DL and LLM, but that isn't always the case.

Ethics and Challenges of Implementation



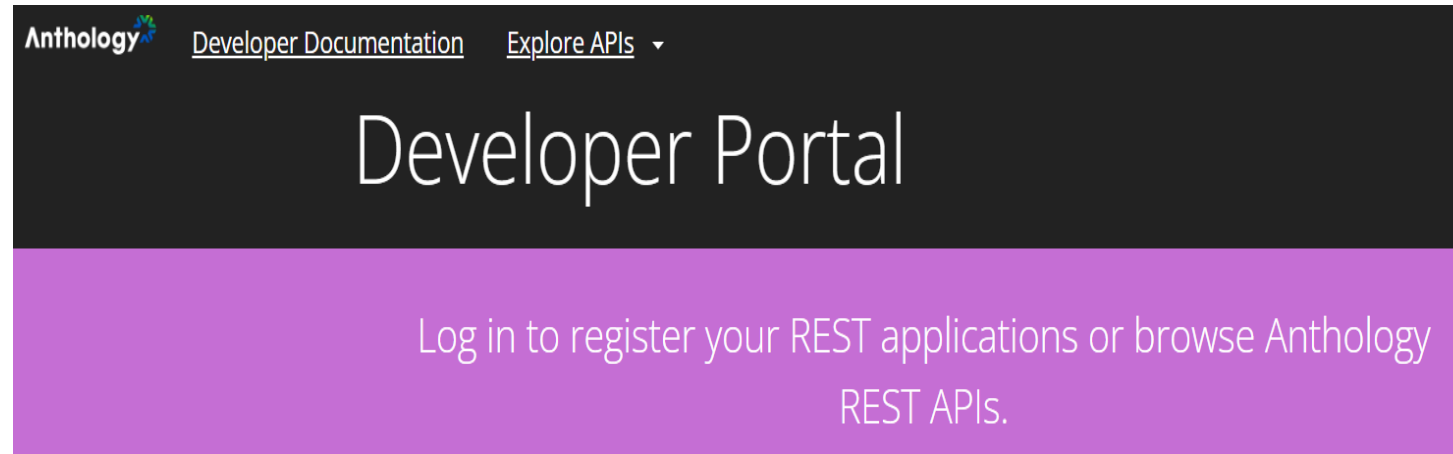
Conceptual Foundations

- Key Rationales

- Neurocognitive

Framework

Learning Management System Compatibility and Web Application Advantages



Blackboard

Expand on our LMS' capabilities by using LTI and the API to create users, pull assessments, grade data, manage calendars, and more.

[Documentation →](#)

Student

Use Anthology Student APIs to increase institution efficiency through automation and optimization.

[Documentation →](#)

Anthology Ally

Improve the accessibility of institutional content by using the API to upload files, check the status and retrieve reports.

[Documentation →](#)

Conceptual Foundations: Key Rationales, and Neurocognitive Framework

Close Proximal Placement to Course Material

 Southern Connecticut State University

-  Institution Page
-  Michael Aiello
-  Activity
-  Courses
-  Organizations
-  Calendar
-  Grades
-  Tools
-  Sign Out

[Privacy](#)
[Terms](#)
[Accessibility](#)

Page 1 of 1

Discovering Blackboard Learn

Blackboard Learn from scratch - Policies & Procedures

- a. User Guides
- b. User credentials
- c. Navigation to the user account
- d. Profile
- e. Send email - VTBE
- f. Navigation to a course as a student
 - i. Submit as a student:
 - 1. BB assignment
 - 2. Turnitin assignment
 - 3. Test

Assignment Details

GRADE
LAST GRADED ATTEMPT - /100

ATTEMPT 3
8/5/20 2:25 PM /100

SUBMISSION

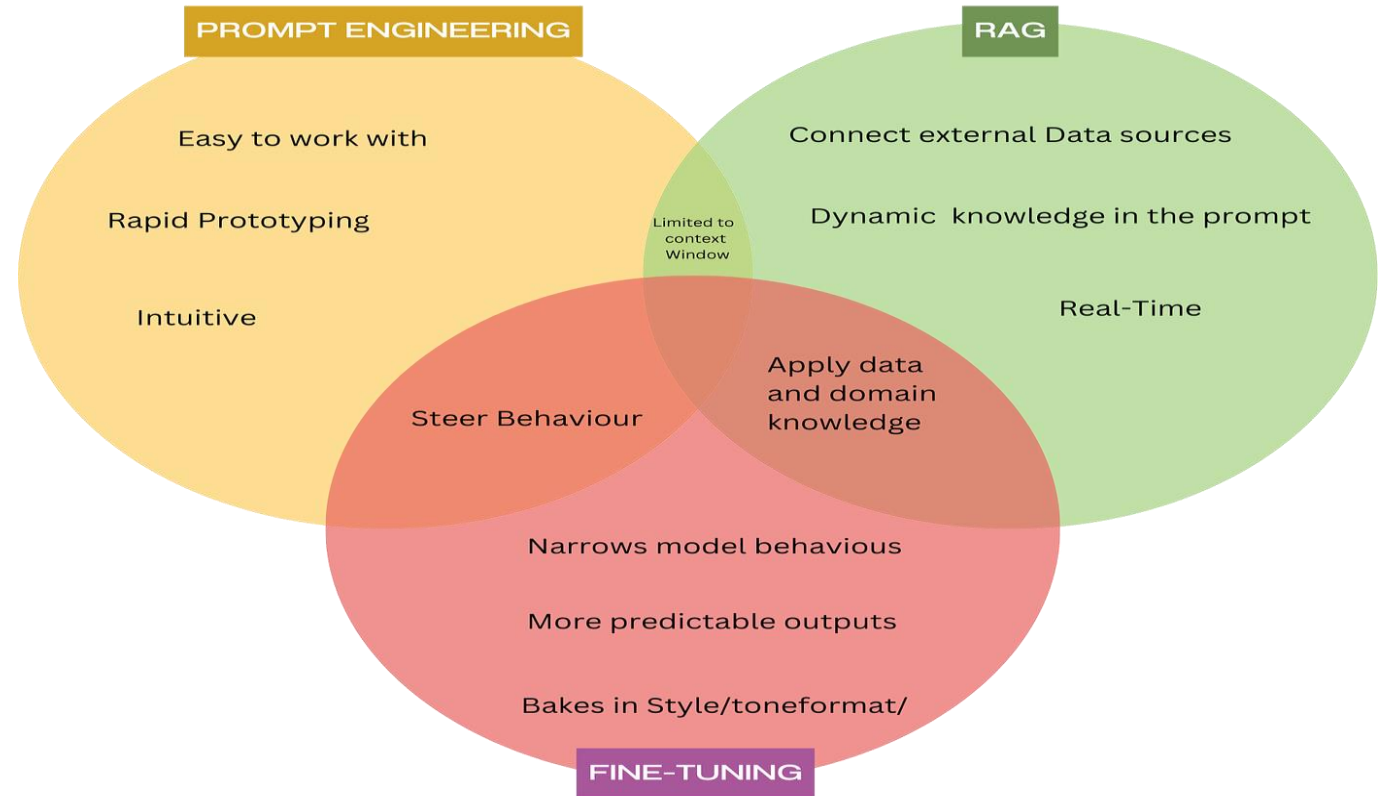
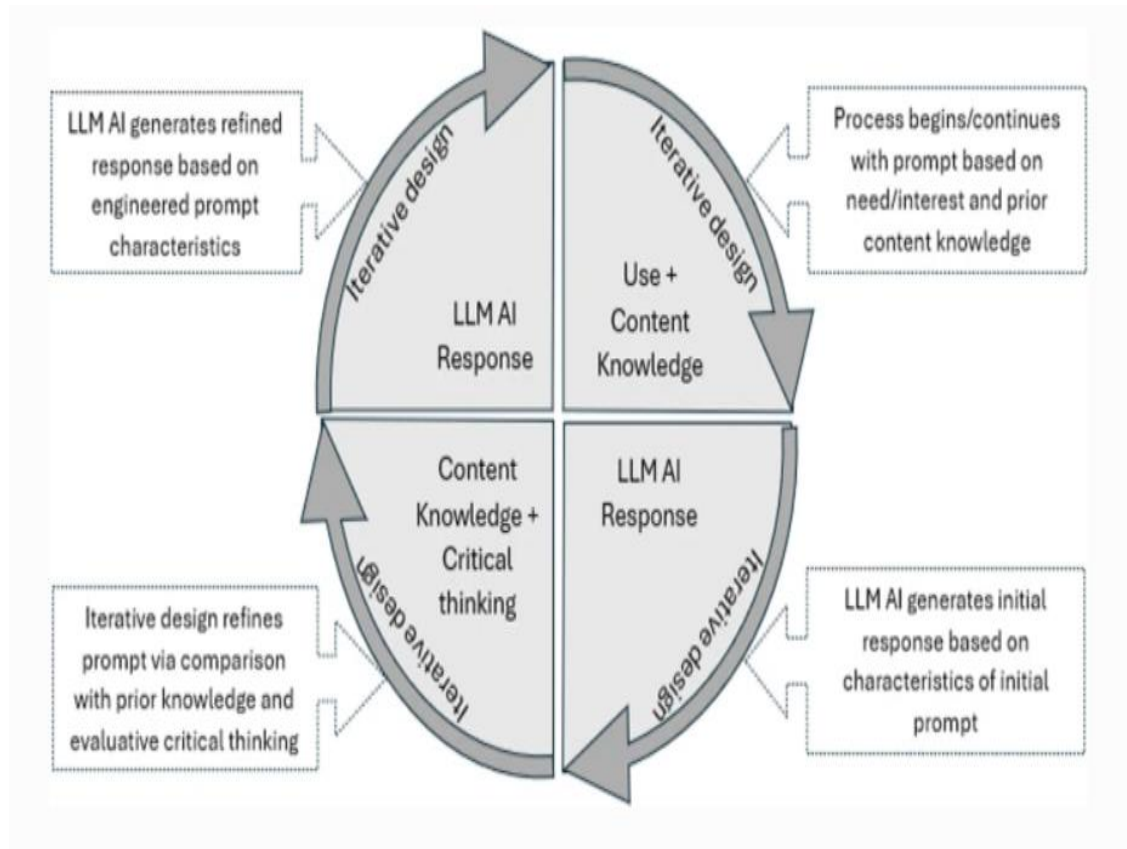
 [TRAINING PROGRAM.docx](#) 

Submitted file

OK Start New

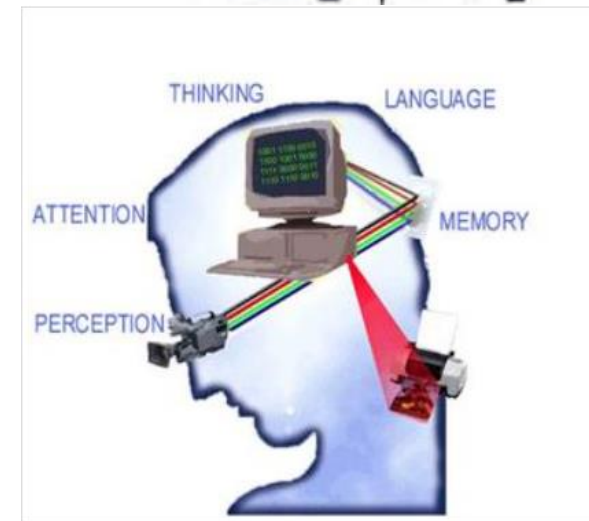
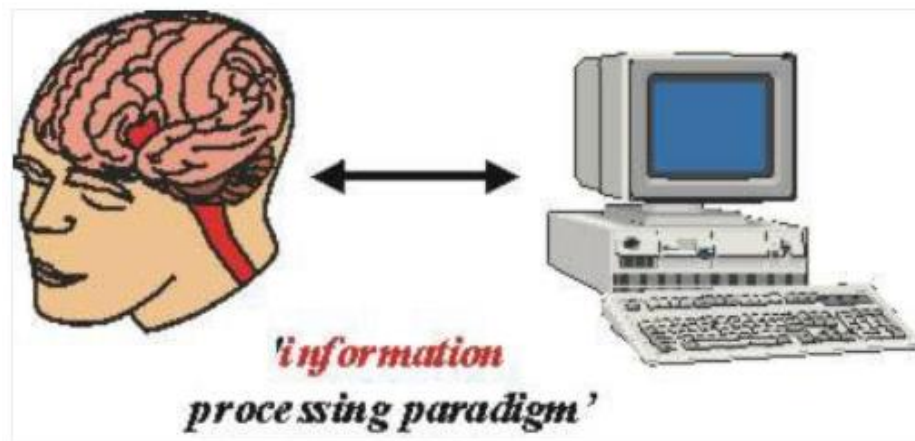
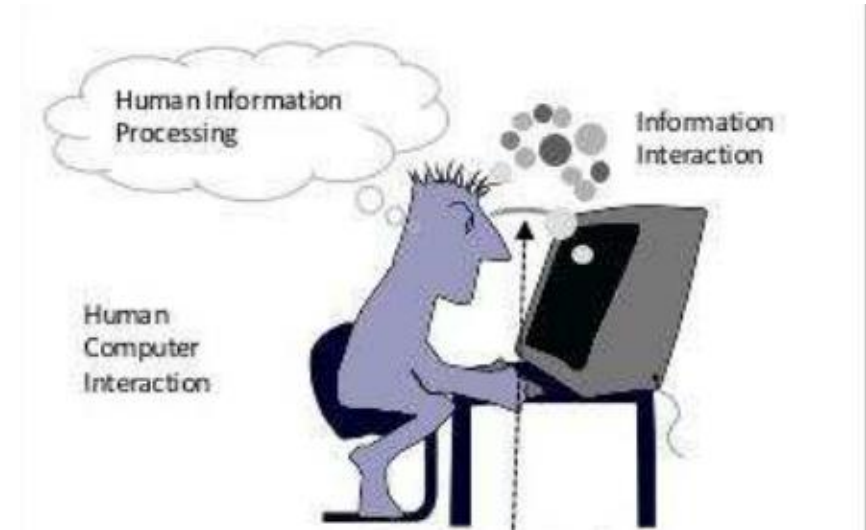
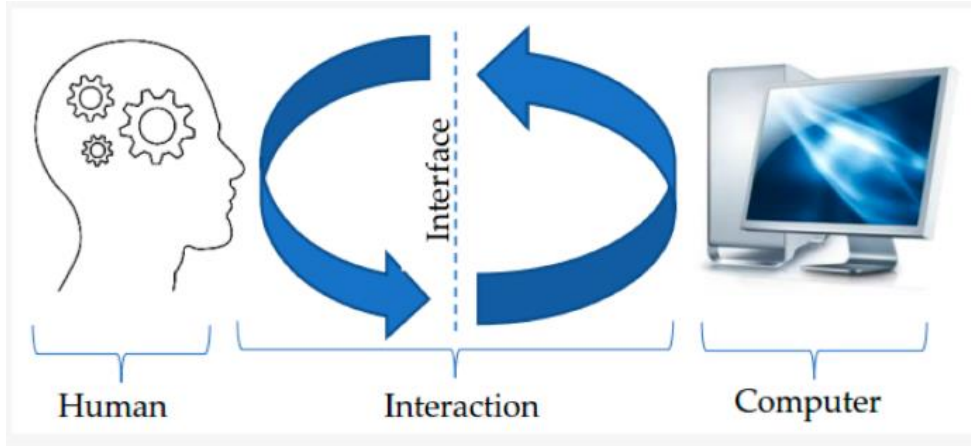
Start an new file submission

Data Contextualization and Instruction Based Prompt Engineering for Fine-tuned Responses

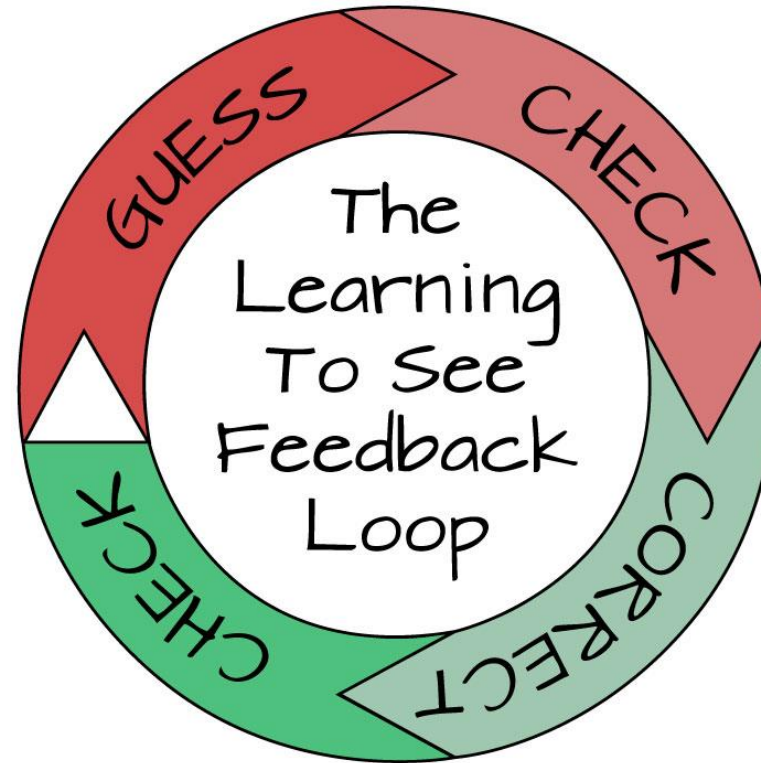
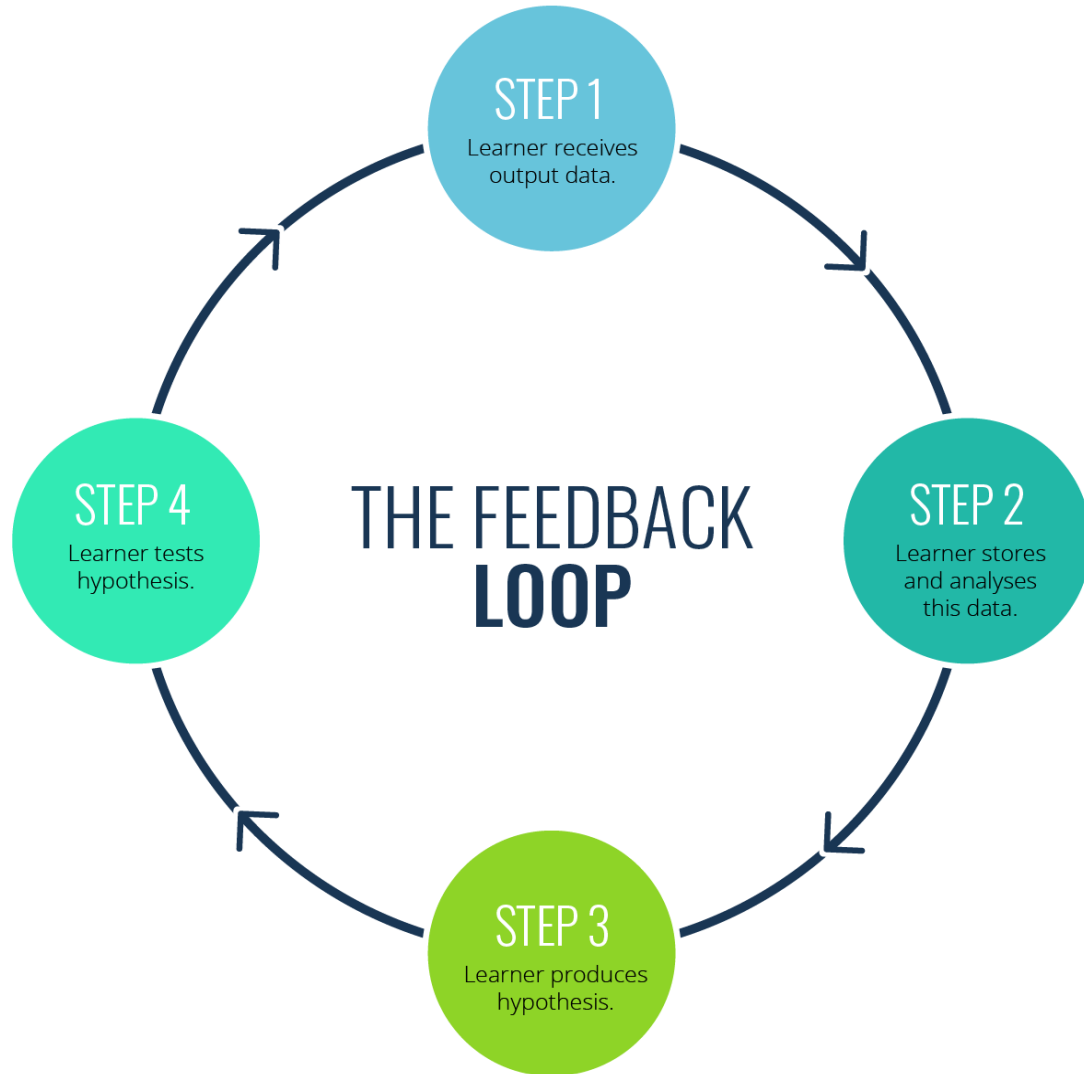


Conceptual Foundations: Key Rationales, and Neurocognitive Framework

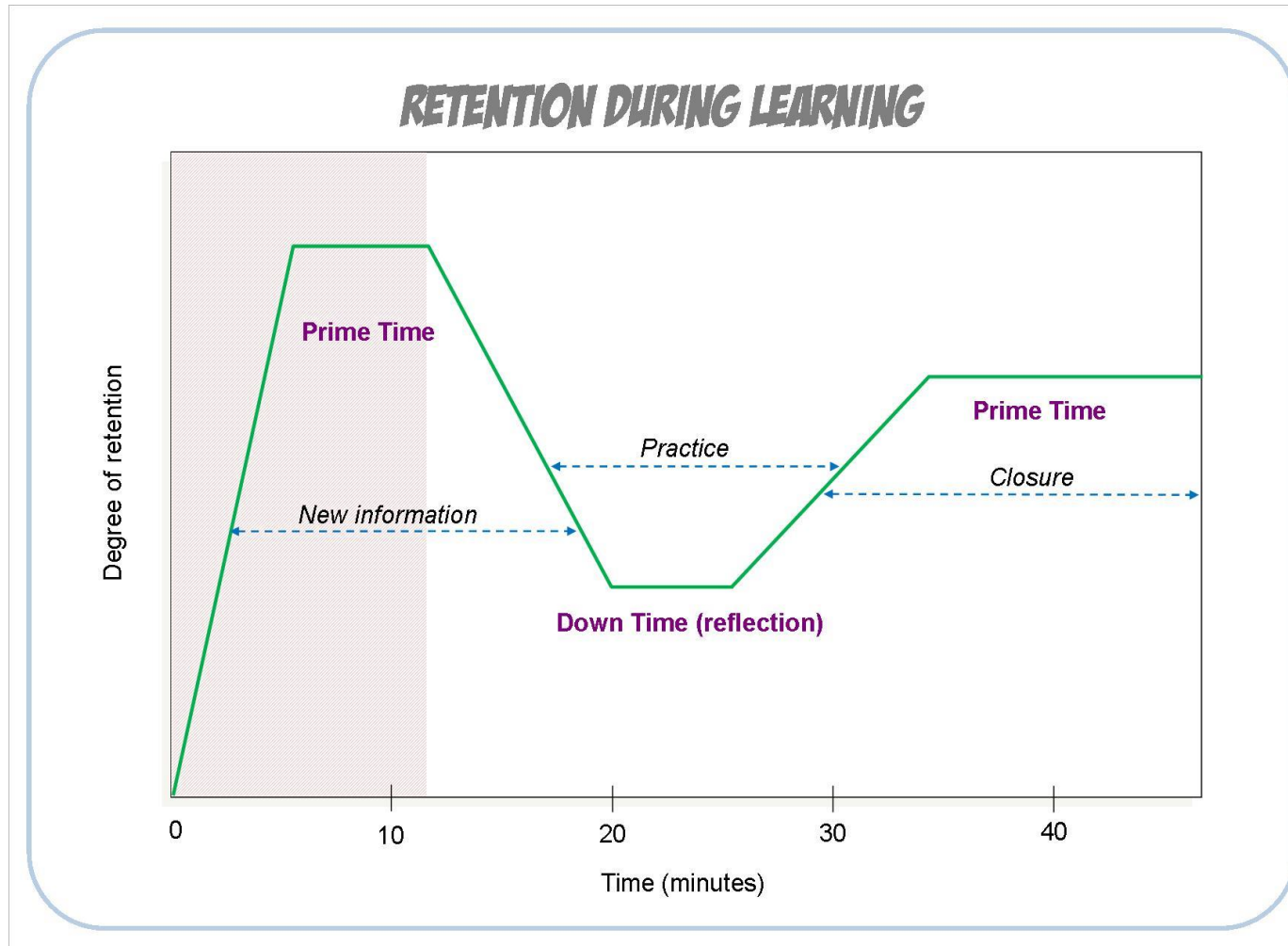
Neurocognitive Psychological Science of Information Processing



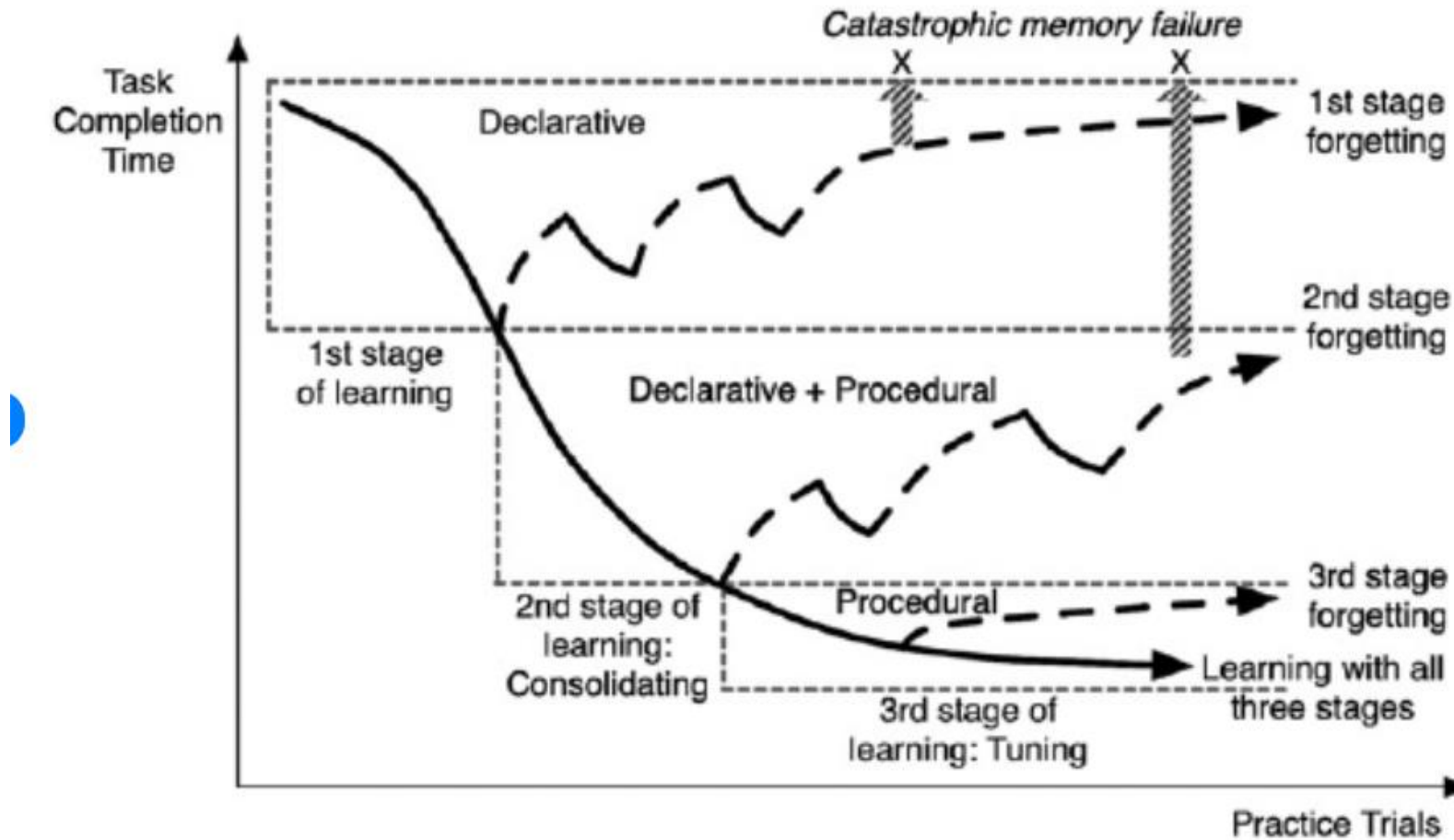
Dopaminergic Feedback Engagement Loop



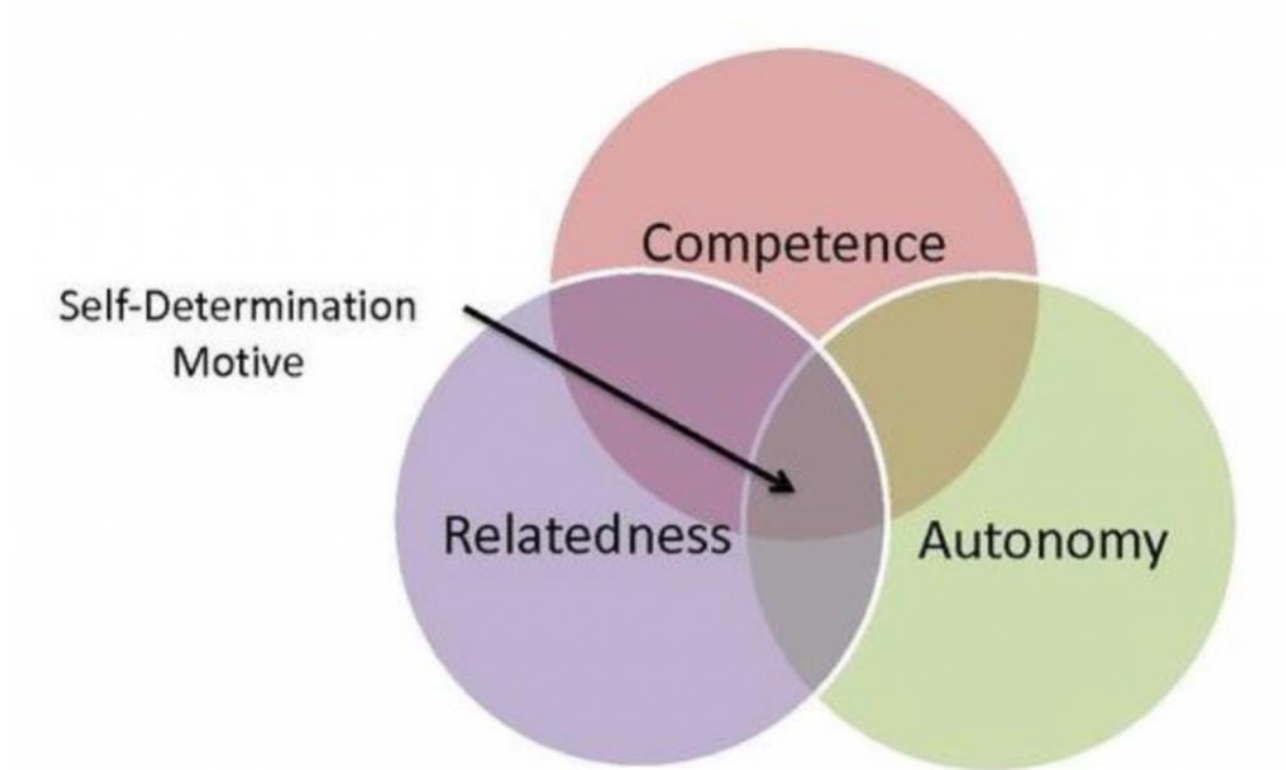
Knowledge Retention



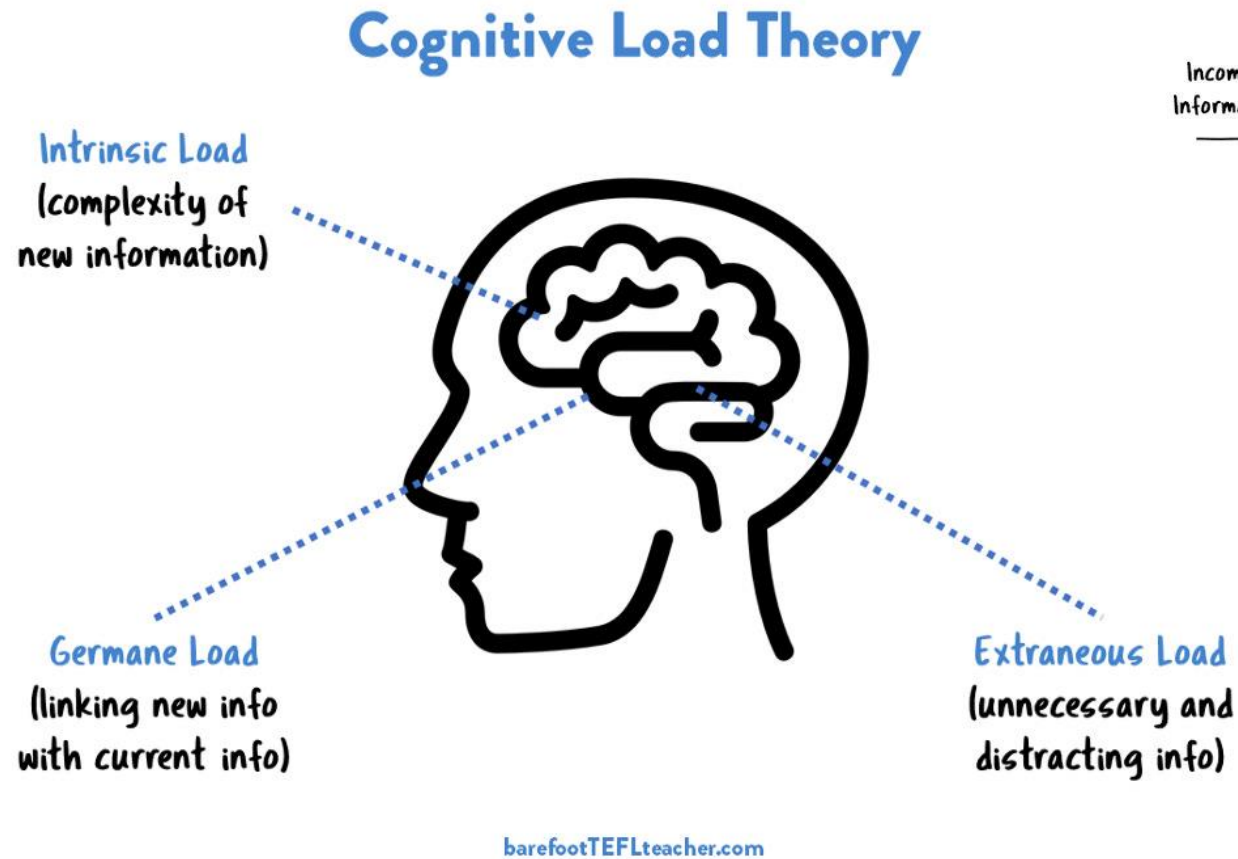
Consolidation



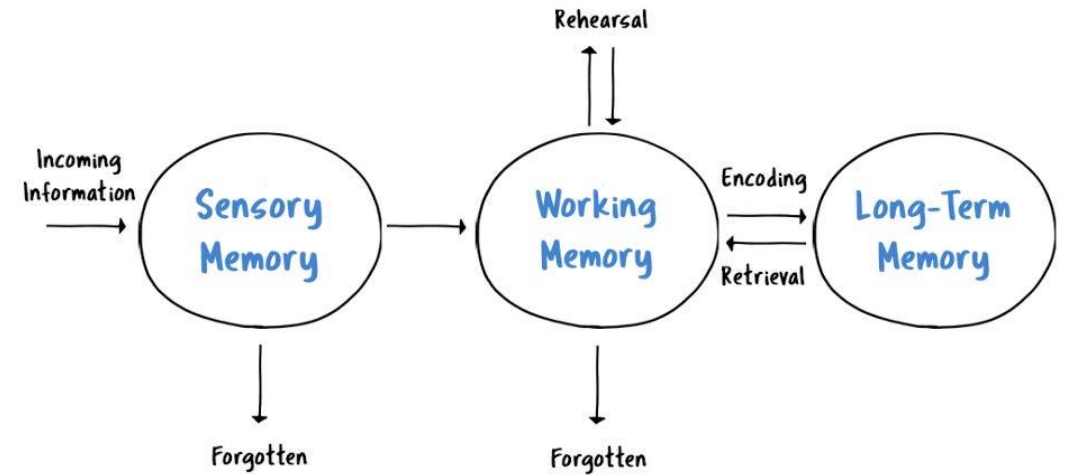
Self-Determination Theory



Cognitive Load Theory



Information Processing Model



Advocation of Proper AI Use for Positive Learning Outcomes



Conceptual Foundations: Key Rationales, and Neurocognitive Framework

Design and Implementation

- User Stories

- RAG System

- Project Organization

User Stories Purpose and Definition

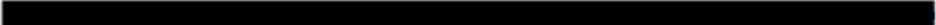
As a <user role>

I want <goal>

so that <benefit>.

User Stories: Account Management

4.2.1.a. Account Management (Student + Educator + Admin)

- A1. As a student, I should be able to log in using my email and password, so that I can access the main functional components of the application for course interaction. (Figure 1)
 - A2. As an educator, I should be able to log in using my email and password, so that I can access the main functional components of the application for course management and student oversight. (Figure 1)
- 
- 
- 

- A3. As an admin, I should be able to log in using my username and password, so that I can access the administrative panel for system management. (Figure 2)
- A4. As a student, when logged in, I should be able to access my profile data, so that I can manage my login credentials and profile information. (Figure 11)
- A5. As an educator, when logged in, I should be able to access my profile data, so that I can manage my login credentials. (Figure 11)
- A6. As an admin, when logged in, I should be able to access my profile data, so that I can manage my login credentials. (Figure 11)
- A7. As a student, when accessing my profile data, I should be able to update my email and password, so that I can maintain the security of my account. (Figure 11)
- A8. As a student, when accessing my profile data, I should be able to include and/or update my profile information that consists of my major, minor, research interests, and career plans/goals so as to later provide LLM context for relevant responses. (Figure 11)
- A9. As an educator, when accessing my profile data, I should be able to update my email and password, so that I can maintain the security of my account. (Figure 11)
- A10. As an admin, when accessing my profile data, I should be able to update my email and password, so that I can maintain the security of my account. (Figure 11)

User Stories: Course Access and Navigation

4.2.1.b. Course Access + Navigation (Student + Educator)

- B1. As a student, when logged in, I should be able to access a list of courses I am enrolled in (preconfigured in DB), so that I can easily find and navigate to a course. (Figure 4, Figure 5)
- B2. As a student, when accessing the list of courses, I should be able to select one, so that I can enter a specific course environment for interaction. (Figure 5, Figure 6)
- B3. As a student, after selecting a course, I should be directed to the main course page if I am enrolled in that course, so that I can begin interacting with the course. (Figure 6)
- B4. As a student, once on the main course page, I should be able to view and select a course material. (Figure 7)
- B5. As an educator, when logged in, I should be able to access a list of courses I have been assigned to teach (preconfigured in DB), so that I can easily find and navigate to a course. (Figure 5)
- B6. As an educator, when accessing the list of courses, I should be able to select one, so that I can enter a specific course environment for managing and interaction. (Figure 5)
- B7. As an educator, after selecting a course, I should be directed to the main course page if I am assigned to teach that course, so that I can begin managing and interacting with the course. (Figure 6)
- B8. As an educator, once on the main course page, I should be able to view and select a course material. (Figure 7)

User Stories: Content Interaction and LLM Tool

4.2.1.c. Student: Content Interaction + LLM Tool

- C1. As a student, when interacting with the course material section, I should be able to select a course material from a list of supported formats and have it displayed or played in a viewer/player component, as well as have the ability to download a copy of the material. (Figure 6, Figure 7)
 - C2. As a student, when interacting with a selected material, I should be able to save notes and questions I have on the material by typing into an assistive LLM tool using the command triggers \note or \question followed by the content. (Figure 7)
 - C3. As a student, I should be able to type any question into the assistive LLM tool, and have it respond with a regulated, fine-tuned response. (Figure 7)
 - C4. As a student, I should be able to view, update, and delete my saved notes and questions for a course. (Figure 8, Figure 9)
 - C5. As a student, I should be able to filter and search my notes and questions using keywords or by selecting a specific material from a dropdown. (Figure 8, Figure 9)
- 
- 
- 

- C6. As a student, I should be able to use the \relevance command to ask how course content relates to my academic and career interests. (Figure 7, Figure 10)
- C7. As a student, I should be able to use the \feedback command to provide feedback about the AI system. (Figure 18, Figure 19)
- C8. As a student, I should be able to view my saved relevance responses in a dedicated section. (Figure 10)

User Stories: Educator Course Management and Student Oversight

4.2.1.d. Educator: Course Management + Student Oversight

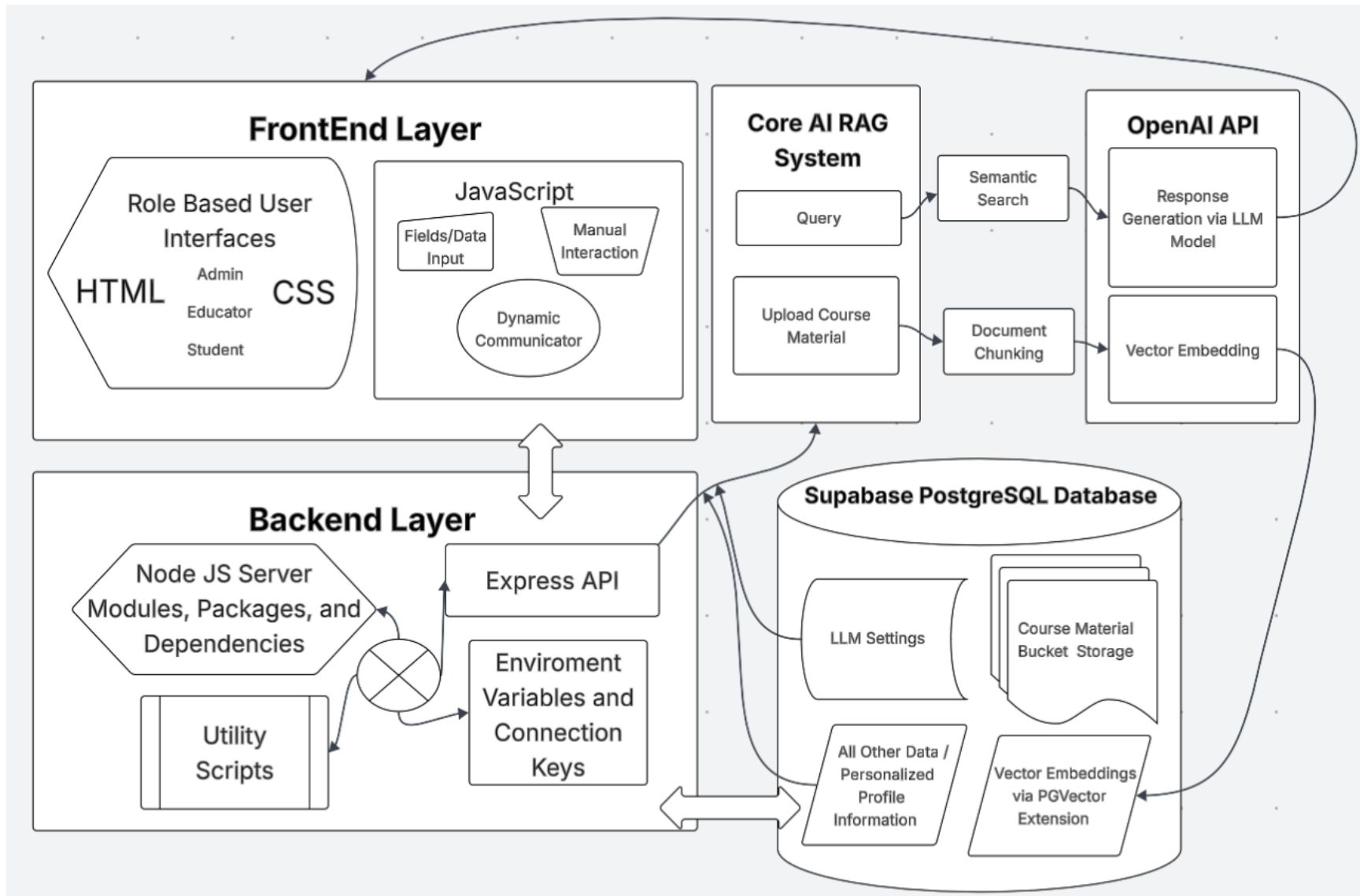
- D1. As an educator, I should be able to upload course materials in supported formats to an organized selectable list on the course material section page. (Figure 12)
- D2. As an educator, I should be able to view or play a selected course material in a viewer/player component and download it. (Figure 6)
- D3. As an educator, I should be able to view a list of students enrolled in my course. (N/A – Figure not included in current set)
- D4. As an educator, I should be able to view individual student profiles and see their notes and questions for the course. (Figure 8, Figure 9)
- D5. As an educator, I should be able to view and respond to questions students asked me. (Figure 9)
- D6. As an educator, I should be able to use the LLM tool to ask questions about course content. (Figure 7)
- D7. As an educator, I should be able to use the \feedback command to provide feedback about the AI system. (Figure 18, Figure 19)

User Stories: Admin System Management and Analytics

4.2.1.e. Admin: System Management + Analytics

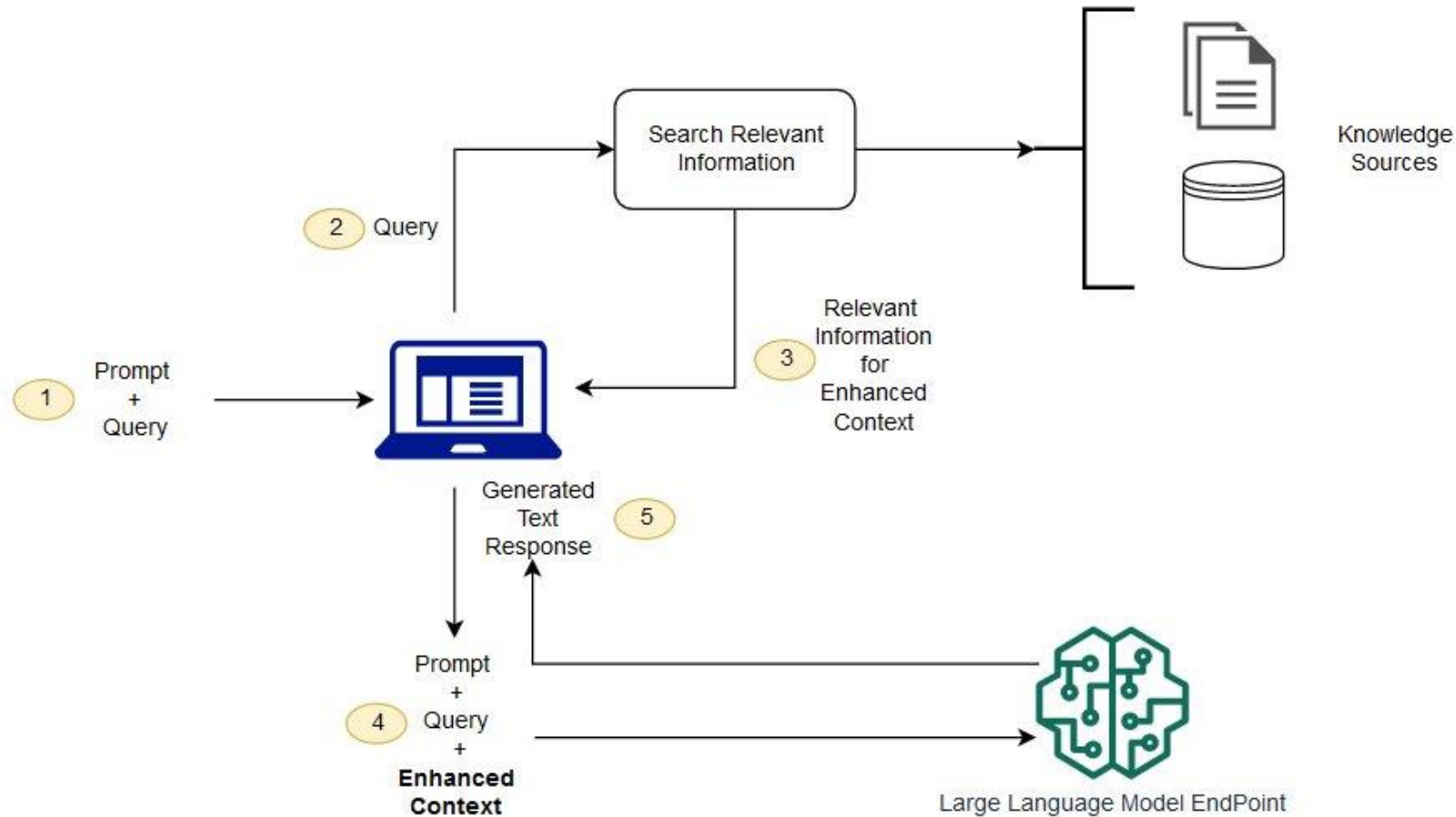
- E1. As an admin, I should be able to manage schools by adding, editing, and deleting school information. (Figure 14)
- E2. As an admin, I should be able to manage students by adding, editing, and deleting student accounts. (Figure 12)
- E3. As an admin, I should be able to manage educators by adding, editing, and deleting educator accounts. (N/A – Figure not included in current set)
- E4. As an admin, I should be able to manage courses by adding, editing, and deleting course information. (N/A – Figure not included in current set)
- E5. As an admin, I should be able to manage course enrollments by adding and removing students from courses. (Figure 15)
- E6. As an admin, I should be able to configure LLM settings including model parameters, embedding models, and system prompts. (Figure 16)
- E7. As an admin, I should be able to view and analyze feedback from students and educators. (Figure 18)
- E8. As an admin, I should be able to enable or disable specific features like relevance analysis. (Figure 16)

Core System Architecture



Design and Implementation: User Stories, RAG System, and Project Organization

Retrieval Augmented Generation (RAG) System



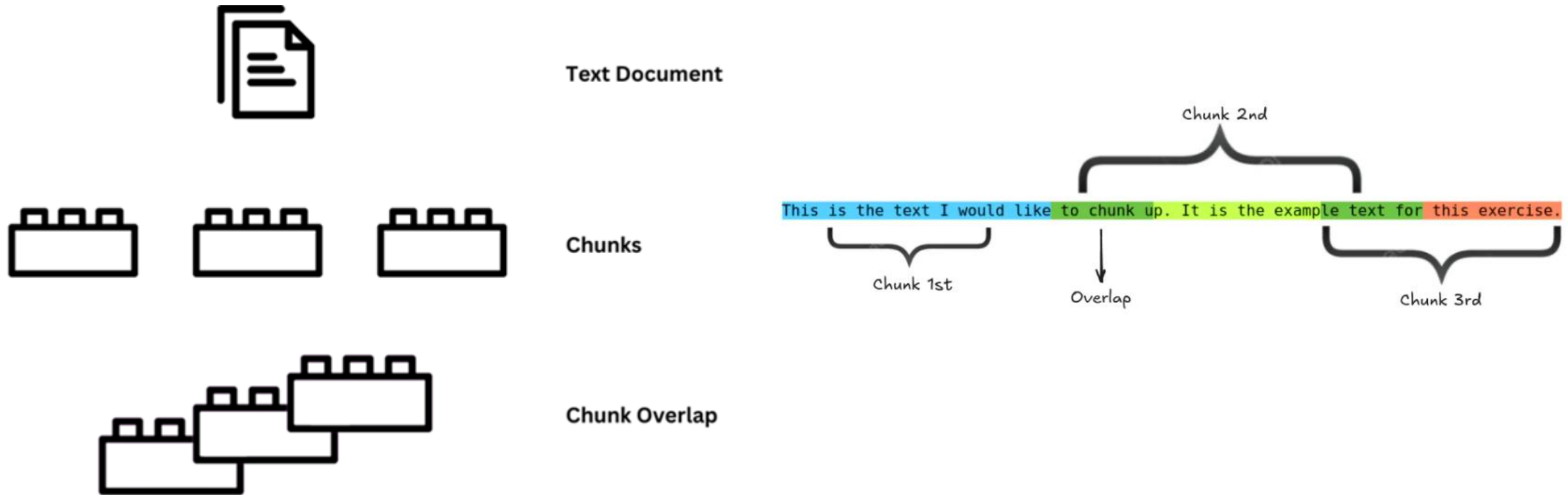
RAG: Tokens

Tokens	Characters
95	444

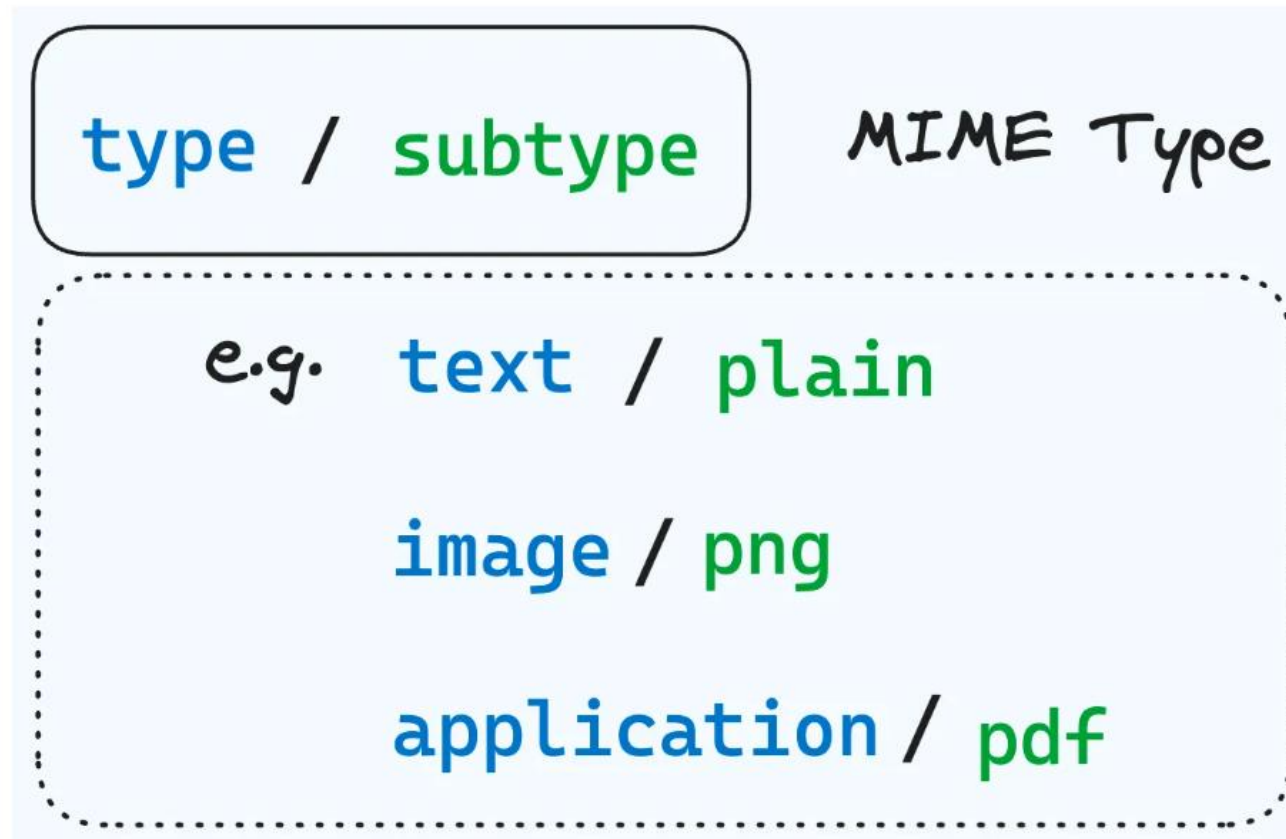
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum

TEXT TOKEN IDS

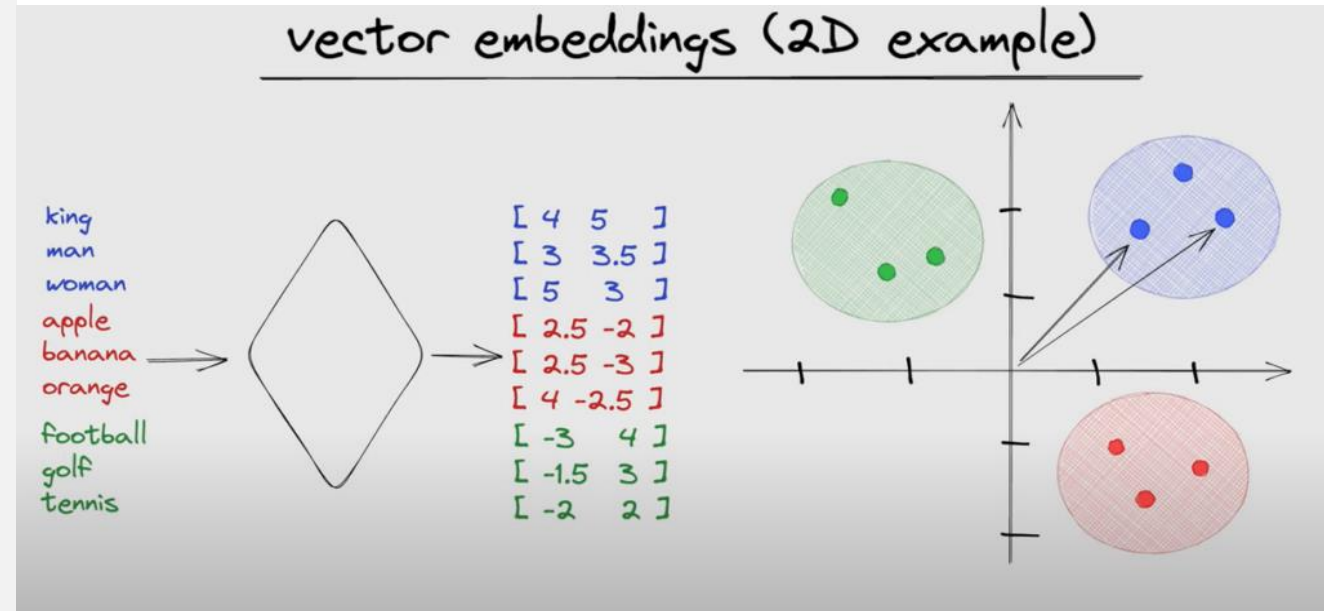
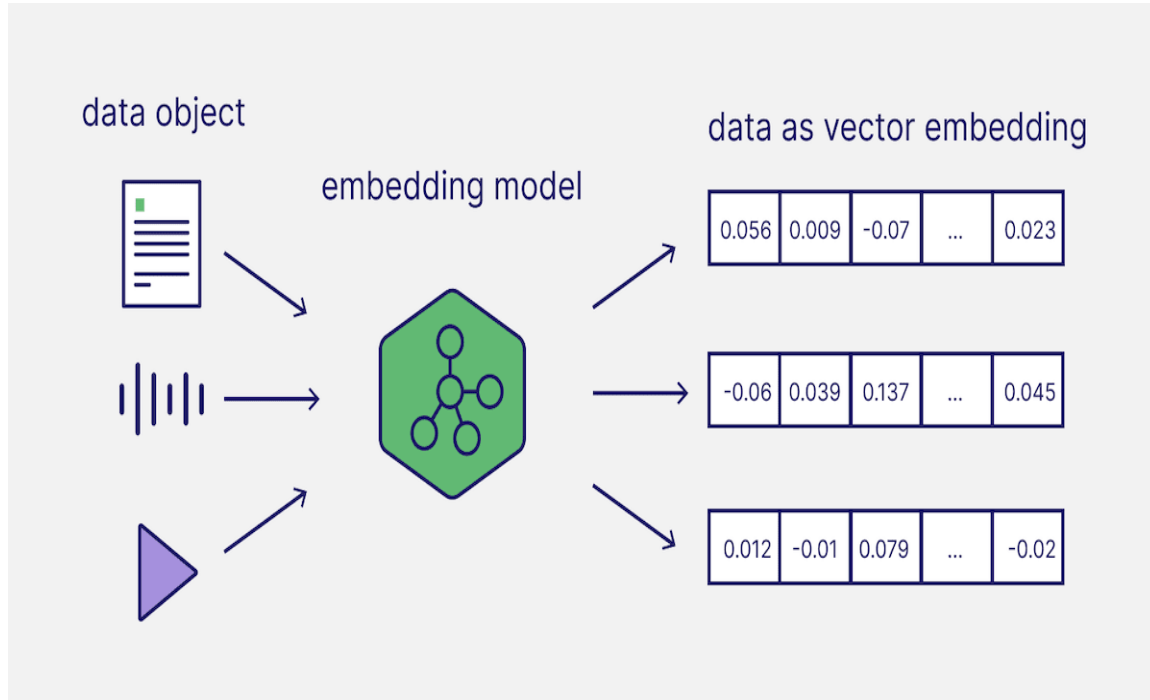
RAG: Document Chunking



RAG: Document Chunking – MIME Types

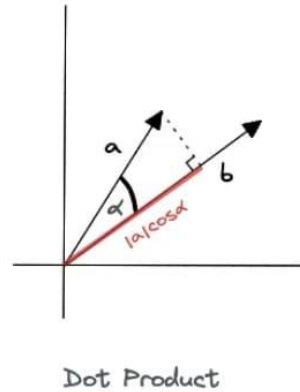
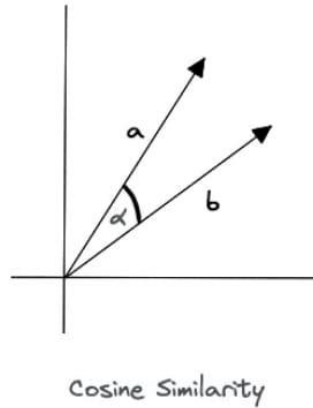
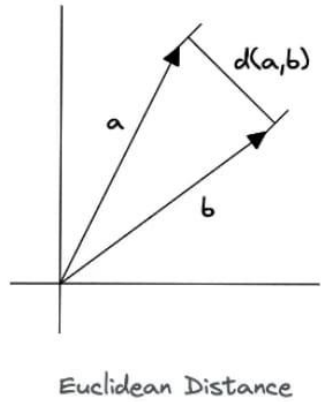


RAG: Vector Embeddings

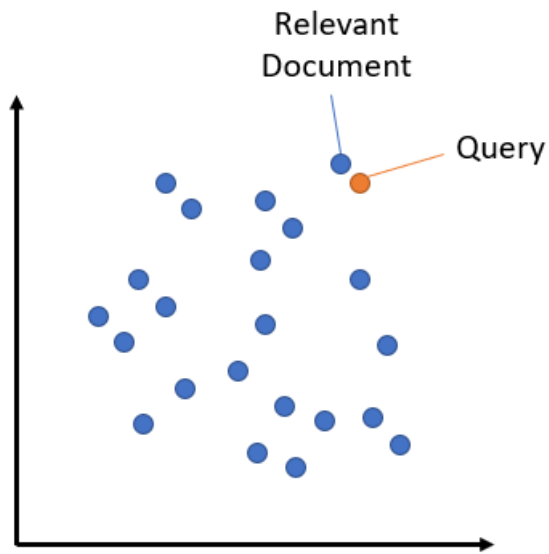
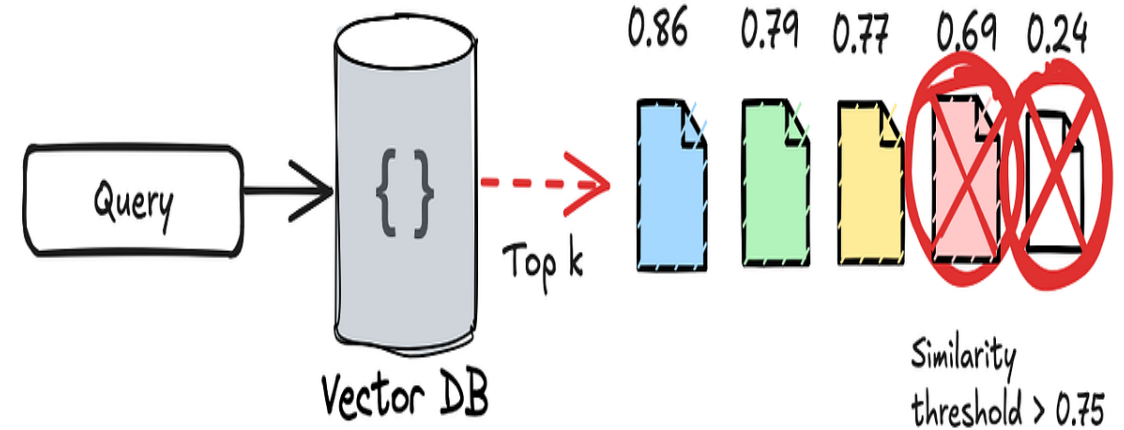


RAG: Retrieval Mechanism – Similarity Search

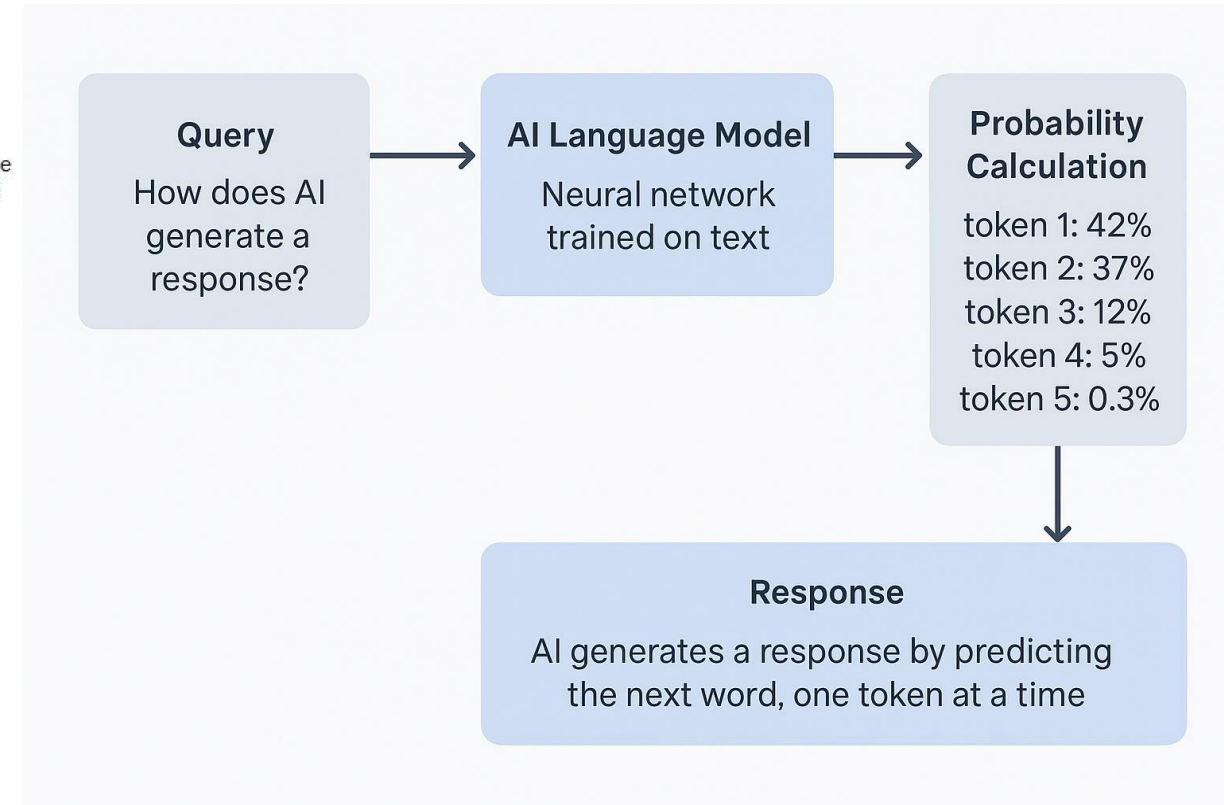
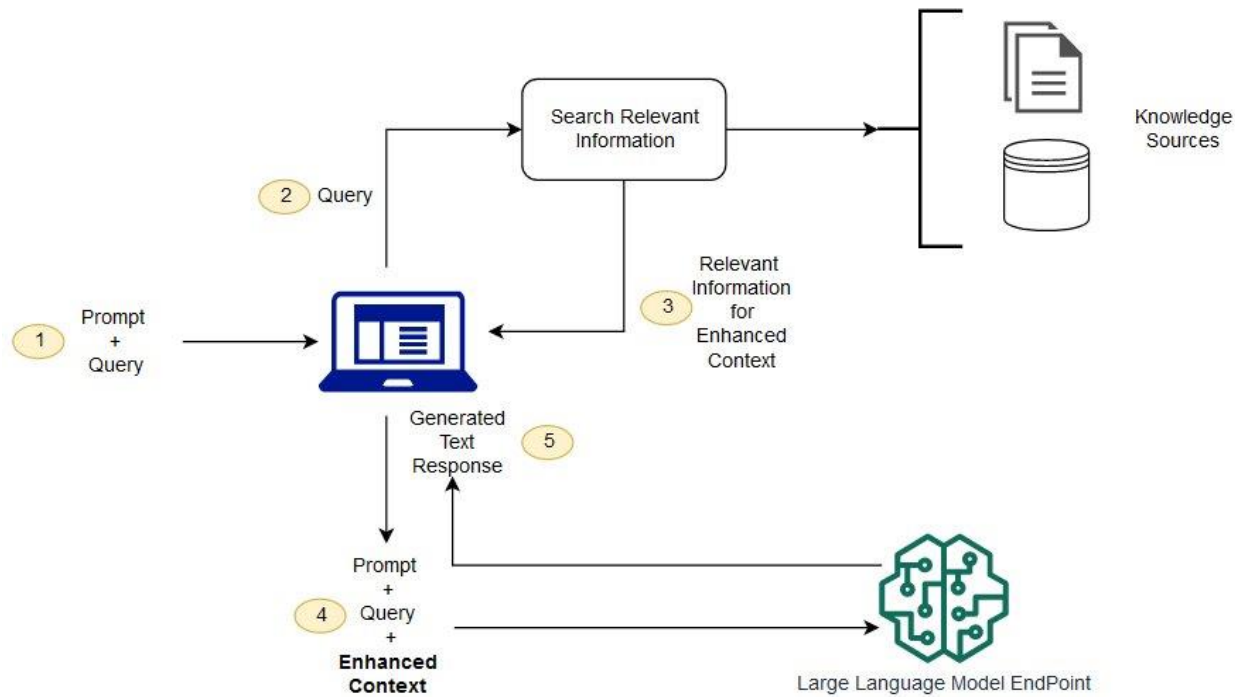
Similarity Metrics



Similarity with threshold Retrieval

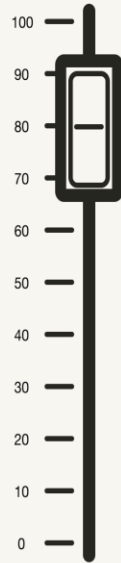


RAG: Response Generation

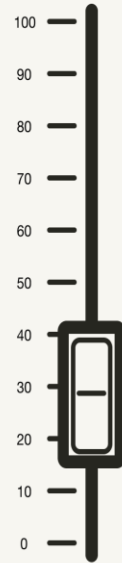


RAG: Parameter Finetuning

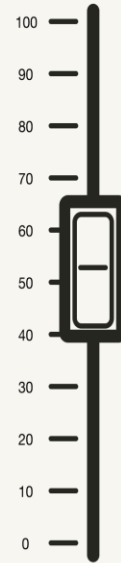
Retrieval



Augmentation

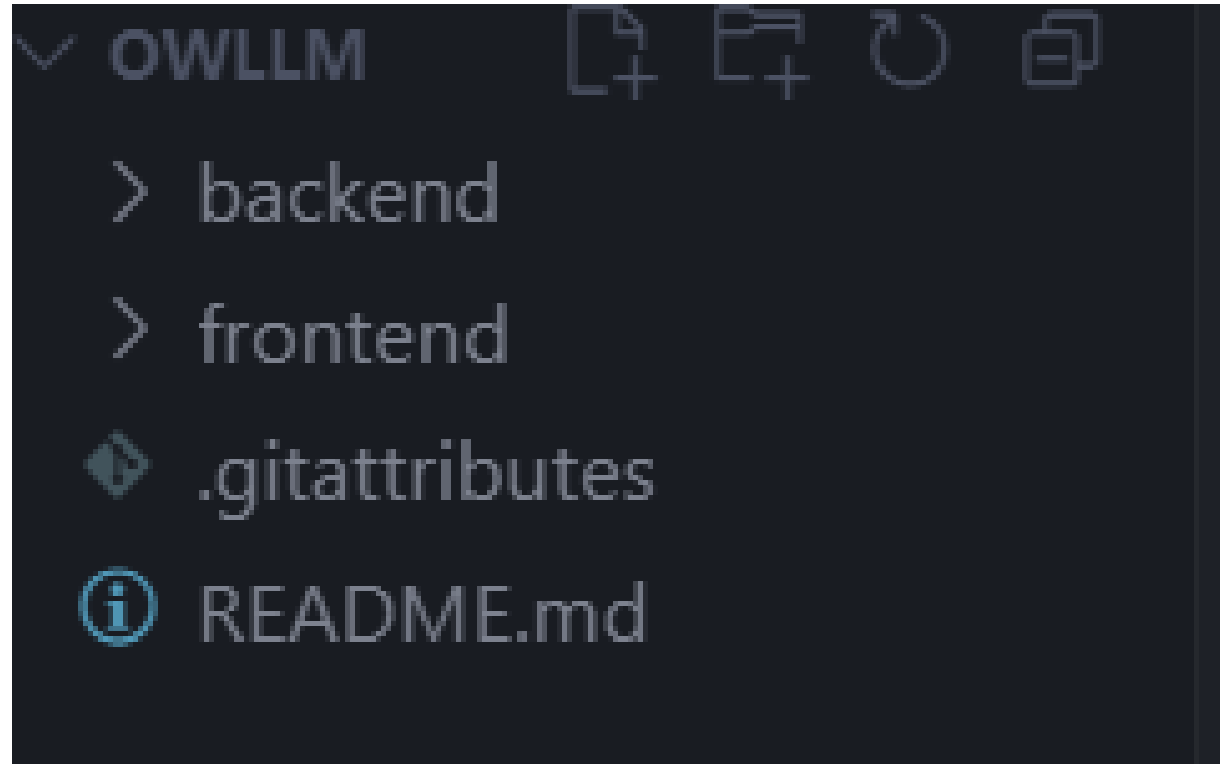


Generation

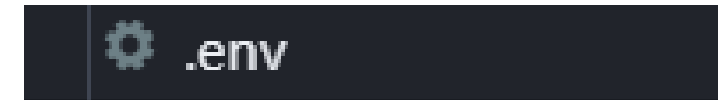
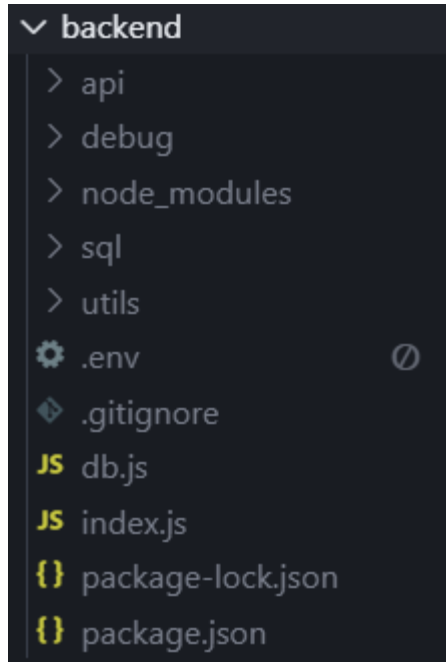


Chunk # of Tokens
Overlap # of Tokens
Temperature
Top P
Frequency Penalty
Prescence Penalty
Max Context Chunks
Max Context Length
Top K Results
Distance Metric
System Prompts
User Role Prompts

Project Organization: Root Level



Project Organization: Backend - Core



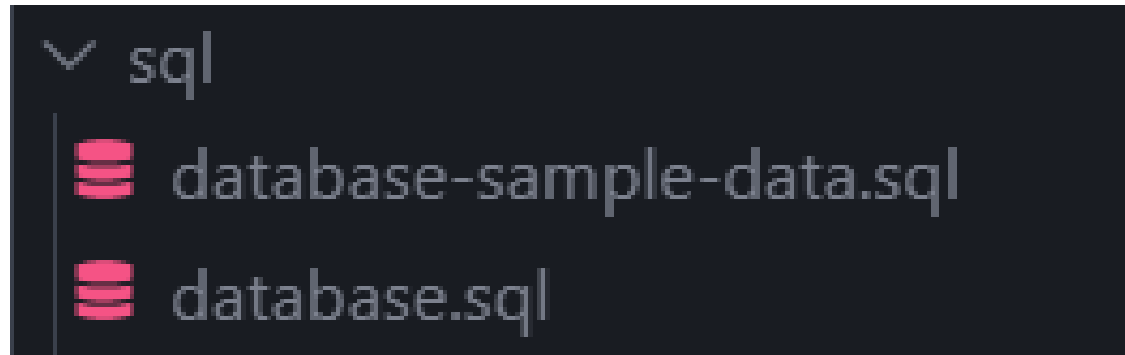
Project Organization: Backend – API Layer



Project Organization: Backend – Utility Scripts



Project Organization: Backend – SQL Folder

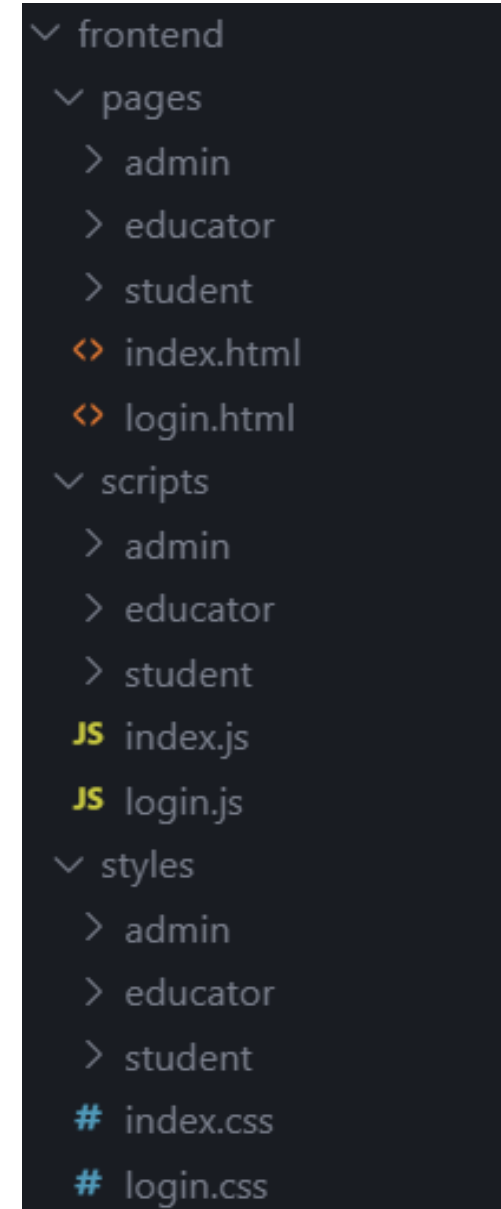
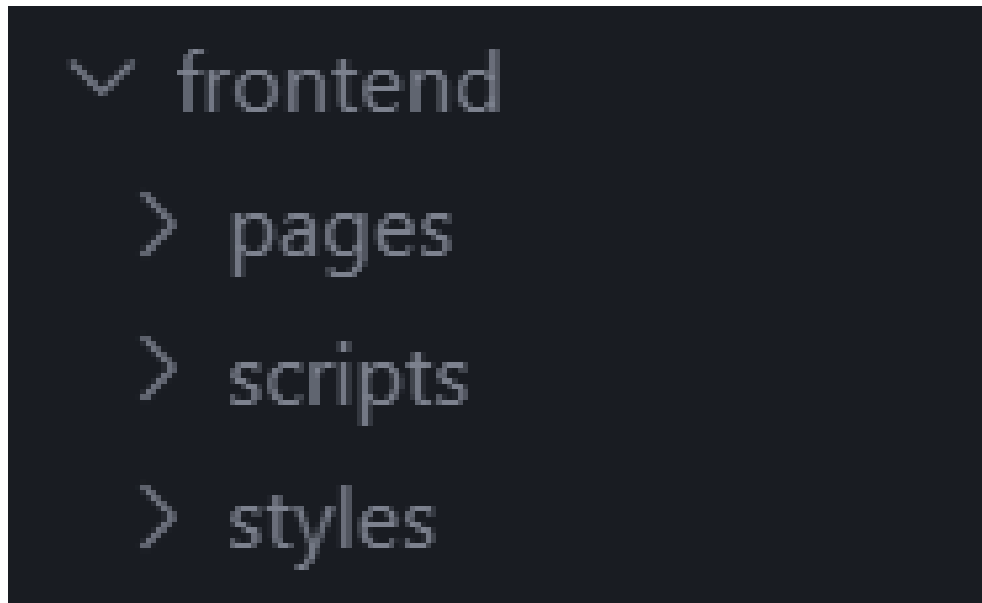


Project Organization: Backend – Debugging

```
▼ debug
JS check-bucket-config.js
JS check-llm-settings.js
JS cleanup-llm-functions.js
JS debug-rag-system.js
JS debug-similarity.js
JS debug-youtube-formats.js
JS fix-doc-processing.js
JS fix-image-processing-function.js
JS rag-diagnostic.js
JS test-admin-api.js
JS test-admin-endpoints.js
JS test-copy-prevention.js
JS test-document-specific-rag.js
JS test-educator-engagement-endpoint.js
JS test-feedback-params.js
JS test-feedback-system.js
JS test-llm-function.js
JS test-m4a-processing.js
```

```
JS test-mime-types.js
JS test-new-bucket.js
JS test-regular-upload.js
JS test-relevance-command.js
JS test-student-rag.js
JS test-supabase-upload.js
JS test-upload-with-duplex.js
JS test-youtube-download.js
JS test-youtube-endpoint.js
JS test-youtube-frontend.js
JS test-youtube-function.js
JS test-youtube-upload-simulation.js
JS update-llm-settings.js
```

Project Organization: Frontend



Demo

<http://34.132.142.139:5000/pages/index.html>

Admin Login -

Username: admin

Password: admin123

Default Logins -

Username/Email: School Email

Password: {user role}123

AI-Assisted Development

Open Up CursorIDE

Supabase PostgreSQL Database

<https://supabase.com/dashboard/project/bjpbzrheuzthfhltduko/database/schemas>

Testing and Evaluation

- User Story Matrix

- Strengths and Weaknesses

- Limitations

User Story Matrix

ID	Scenario	Figure(s)	Result	Evaluator Notes
A1	Student login with email/password	Fig. 1	Passed	All functionalities confirmed
A2	Educator login with email/password	Fig. 1	Passed	All functionalities confirmed
A3	Admin login with username/password	Fig. 2	Passed	All functionalities confirmed
A4	Student access profile data	Fig. 11	Passed	All functionalities confirmed
A5	Educator access profile data	Fig. 11	Passed	All functionalities confirmed
A6	Admin access profile data	Fig. 11	Passed	All functionalities confirmed
A7	Student update email/password	Fig. 11	Passed	All functionalities confirmed
A8	Student update profile information (major, minor, interests, goals)	Fig. 11	Passed	All functionalities confirmed
A9	Educator update email/password	Fig. 11	Passed	All functionalities confirmed
A10	Admin update email/password	Fig. 11	Passed	All functionalities confirmed
B1	Student access list of enrolled courses	Fig. 4, Fig. 5	Passed	All functionalities confirmed
B2	Student select a course	Fig. 5, Fig. 6	Passed	All functionalities confirmed
B3	Student directed to main course page	Fig. 6	Passed	All functionalities confirmed
B4	Student view and select course material	Fig. 7	Passed	All functionalities confirmed
B5	Educator access list of assigned courses	Fig. 5	Passed	All functionalities confirmed
B6	Educator select a course	Fig. 5	Passed	All functionalities confirmed
B7	Educator directed to main course page	Fig. 6	Passed	All functionalities confirmed
B8	Educator view and select course material	Fig. 7	Passed	All functionalities confirmed
C1	Student select/display/download course material	Fig. 6, Fig. 7	Passed	All functionalities confirmed
C2	Student save notes/questions using \note or \question	Fig. 7	Passed	All functionalities confirmed
C3	Student ask question with LLM tool and get regulated response	Fig. 7	Partial	Most queries were properly answered, with the occasional hallucination, slightly irrelevant response, or error related to LLM settings and restraints such as max context length that cant be changed via admin settings
C4	Student view, update, and delete saved notes/questions	Fig. 8, Fig. 9	Partial	All functionalities were confirmed except for deleting questions, which is an intended design to consider the importance of questions and how they serve as a dynamic record of evolving understanding, pinpointing areas for deeper exploration.
C5	Student filter/search notes/questions by keyword or material	Fig. 8, Fig. 9	Passed	All functionalities confirmed
C6	Student use \relevance command	Fig. 7, Fig. 10	Passed	All functionalities confirmed
C7	Student use \feedback command	Fig. 18, Fig. 19	Passed	All functionalities confirmed
C8	Student view saved relevance responses	Fig. 10	Passed	All functionalities confirmed
D1	Educator upload course materials	Fig. 12	Passed	All functionalities confirmed
D2	Educator view/play/download selected course material	Fig. 6	Passed	All functionalities confirmed
D3	Educator view list of enrolled students	N/A	Passed	All functionalities confirmed
D4	Educator view student profiles, notes, and questions	Fig. 8, Fig. 9	Passed	All functionalities confirmed
D5	Educator view and respond to student questions	Fig. 9	Passed	All functionalities confirmed
D6	Educator use LLM tool to ask about course content	Fig. 7	Passed	All functionalities confirmed
D7	Educator use \feedback command	Fig. 18, Fig. 19	Passed	All functionalities confirmed
E1	Admin manage schools (add, edit, delete)	Fig. 14	Passed	All functionalities confirmed
E2	Admin manage students (add, edit, delete)	Fig. 12	Passed	All functionalities confirmed
E3	Admin manage educators (add, edit, delete)	N/A	Passed	All functionalities confirmed
E4	Admin manage courses (add, edit, delete)	N/A	Passed	All functionalities confirmed
E5	Admin manage course enrollments	Fig. 15	Passed	All functionalities confirmed
E6	Admin configure LLM settings	Fig. 16	Passed	All functionalities confirmed
E7	Admin view and analyze feedback	Fig. 18	Passed	All functionalities confirmed
E8	Admin enable/disable specific features (e.g., relevance analysis)	Fig. 16	Passed	All functionalities confirmed

AI Interaction and Command Trigger Testing: Command Parsing Accuracy

95%-100%

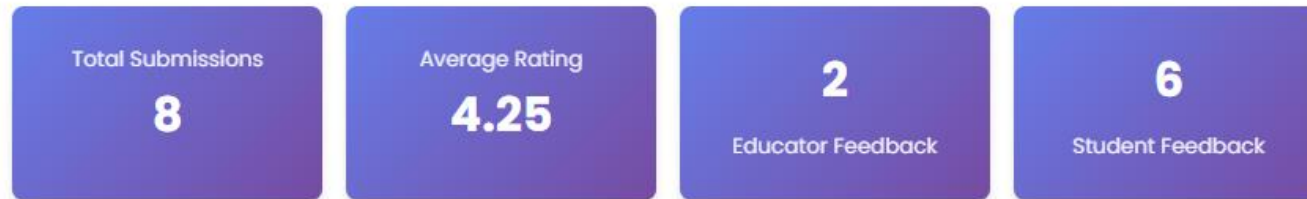
AI Interaction and Command Trigger Testing: Relevance Responses

- Inherently subjective (Needs more evaluation)
- Consistently incorporates and mentions profile information and makes a relative attempt

AI Interaction and Command Trigger Testing: Feedback System Engagement

User Feedback System

View and analyze feedback from students and educators about the AI system performance. This helps identify areas for improvement and user satisfaction.



Not clear if the AI assistant used any contents from the slides.

can see pdf content as well.

I logged in as student and can now see the docx file content.

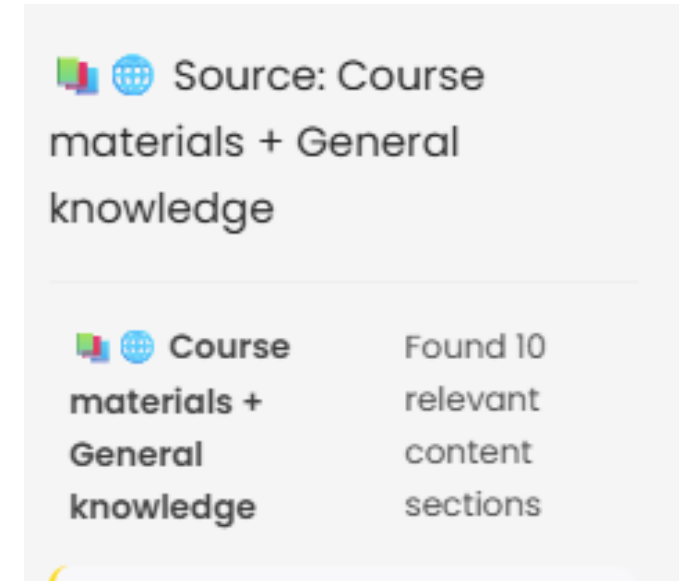
nice job

the youtube was uploaded as a mp4, why only audio? You did say that I will only hear the audio. I am just curious. I will find another mp4 file and check if video works. Good job.

Quite impressive.. I asked the assistant to provide an example of a command that's covered in the material and it did. It was also able to answer questions about commands not covered in the material provided but it correctly pointed out that it wasn't covered when asked.

General Query Response Accuracy

- User Story - "As a student, I should be able to type any question into the assistive LLM tool, and have it respond with a regulated, fine-tuned response."
- Open-ended in nature
- Would require more evaluation / ongoing process
- However, relatively accurate and correct
- Source of response supplement



Summary Analysis and Observations: Strengths

- Role Based Navigation
- Simple Intuitive Interface
- Note and Questions
- Well formatted query = Relatively Strong Contextual Understanding

Summary Analysis and Observations: Weaknesses

- Improperly formatted query = Weak contextual understanding
- Determining learning impact of using tool (Further evaluation needed)
- Not perfectly adaptable to all scenarios
- Inconsistency in functionality / edge cases
- Audio only YouTube video downloads
- Inability to understand visuals within documents
- Cannot handle all specialized academic content formats
- Supabase free tier upload size limit (50mb)

Constraints, and Limitations

- Constrained to intended choice of course path and courses
- Not in a Board of Ed , institutional committee, or staffed worker role
- Proof of concept project as compared to legit implementation
- Shadow doubt and variability in user circumstances

Future Directions

- Research Studies Design
- Extended Functionality
- Scalability

Proposed User Study Design

- Longitudinal study
- Cognitive, Emotional and Behavioral measures
- In-depth methodology
- Ongoing qualitative data
- Ethics
- Goals and objectives

Additional Features and Extended Functionality

- First address the weaknesses and current shortcomings
- Advanced Learning Insights
- Personalized Learning Paths
- Multimodal Content Tools
- Educator Support
- Advanced AI Capabilities

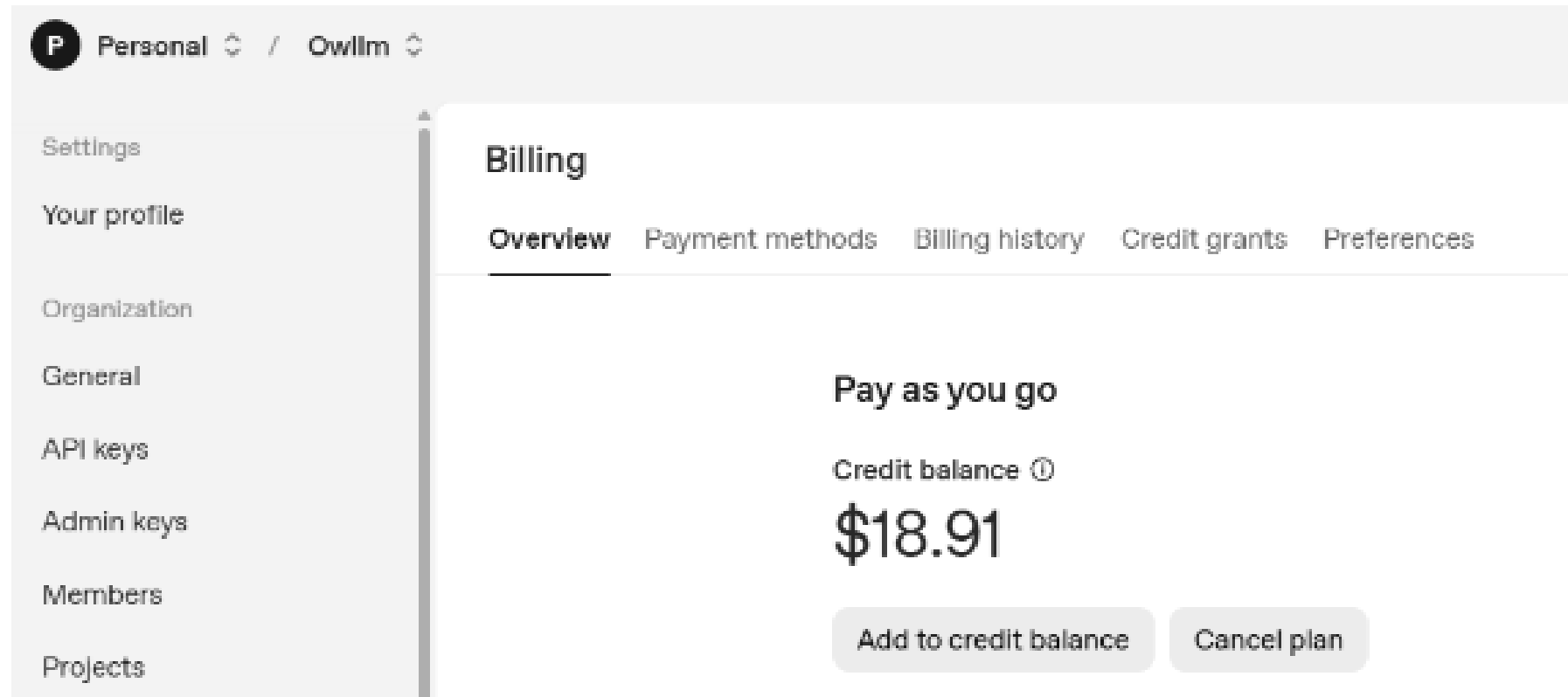
Technical Enhancements and Scalability

- Scalable Architecture
- Offline Capabilities
- Security & Compliance
- LLM Model API Ecosystem
- Performance Optimization

Equity and Accessibility

- Neurodivergent Support
- English Language Learners (ELLs)
- Inclusive Design Goal
- Outcomes

Rough Estimate Cost Breakdown



Future Directions: Research Studies Design, Extended Functionality, Scalability

Rough Estimate Cost Breakdown

$$\text{Total Cost} = \text{Transcription Cost} + \text{Embedding Cost} + \text{Vision Cost} + \text{LLM Usage Cost}$$

Transcription (Whisper):

$$\text{Transcription Cost} = (L \times D_l + V \times D_v) \times C_l$$

L : Number of lectures

D_l : Duration of each lecture (minutes)

V : Number of video assignments

D_v : Duration of each video (minutes)

C_l : Cost per minute of Whisper (approx. \$0.006)

5.3.3.b. B. Embedding (Text, Slides, etc.):

$$\text{Lecture Tokens} = L \times D_l \times \text{WPM} \times T_k$$

$$\text{Textbook Tokens} = \text{Chapters} \times \text{Pages per chapter} \times \text{Words per page} \times T_k$$

$$\text{Slide Tokens} = \text{Slides} \times \text{Words per slide} \times T_k$$

$$\text{Assignment Tokens} = \text{Assignments} \times \text{Words per assignment} \times T_k$$

$$\text{Video Homework Tokens} = V \times D_v \times \text{WPM} \times T_k$$

$$\text{Total Tokens} = \text{Sum of all tokens above}$$

$$\text{Embedding Cost} = \left(\frac{\text{Total Tokens}}{1000} \right) \times C_e$$

T_k : Tokens per word ≈ 1.33

C_e : Embedding cost per 1,000 tokens $\approx \$0.0004$

5.3.3.c. C. Vision (Captured Video Frames for Context):

$$\text{Vision Cost} = S \times F \times C_f$$

S : Number of students

F : Frames captured per student

C_f : Cost per frame $\approx \$0.05$

5.3.3.d. D. LLM Usage (Queries, Feedback, Summarization, Tutoring, etc.):

$$\text{LLM Usage Cost} = Q \times T_q \times \left(\frac{C_q}{1000} \right)$$

Q : Total queries (e.g., per student $\times$ number of students)

T_q : Average tokens per query + response

C_q : Cost per 1,000 tokens (varies by model)

GPT-4o : \$0.02 per 1K tokens

GPT-3.5 : \$0.0035 per 1K tokens

Future Directions: Research Studies Design, Extended Functionality, Scalability

Rough Estimate Cost Breakdown

II. Parameter Sets

5.3.3.e. Less Intensive Course

- $L = 20$, $D_l = 30$ minutes, WPM = 140
- Chapters = 8, Pages per chapter = 8, Words per page = 400
- Slides = 400, Words per slide = 15
- Assignments = 5, Words per assignment = 600
- $V = 5$, $D_v = 5$ minutes
- $S = 30$, $F = 15$
- $T_k = 1.33$
- $Q = 100 \times 30 = 3000$
- $T_q = 700$
- Cost constants: $C_l = 0.006$, $C_e = 0.0004$, $C_f = 0.05$, $C_q = 0.02$

5.3.3.f. More Intensive Course

- $L = 50$, $D_l = 60$ minutes, WPM = 160
- Chapters = 20, Pages per chapter = 15, Words per page = 600
- Slides = 2500, Words per slide = 25
- Assignments = 15, Words per assignment = 1500
- $V = 15$, $D_v = 15$ minutes
- $S = 100$, $F = 30$
- $T_k = 1.33$
- $Q = 300 \times 100 = 30000$
- $T_q = 1000$
- Cost constants: same as above

Component	Less Intensive	More Intensive
Whisper Cost	\$3.90	\$20.70
Embedding Cost	\$0.07	\$0.42
Vision Frame Cost	\$22.50	\$150.00
LLM Usage Cost	\$42.00	\$600.00
Total Cost	\$68.47	\$771.12

Thankyou

Questions?