

# **Artificial Intelligence as Agents to Support Neurodivergent Creative and Critical Thinking Modules**

**by  
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## **Declaration of Committee**

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## **Abstract**

This project is the creation of a minimal viable prototype of an artificial intelligence (AI) model training ecosystem and their supporting applications using the system design approach methodology. The product consists of an online training model platform that allows educators to upload and train education subject matter knowledge to feed into a learning activity generator application. This application will generate a contextual social group activity. The third system is a speech text application that combines the subject matter small data models and generated pre-trained transformer (GPT) to provide conversations that support feedbacks and reflections modules of creative and critical thinking. These products are precursors to conducting further research in the future to explore the socio-environmental and educational barriers experienced by neurodivergent individuals.

**Keywords:** neurodiversity; creative thinking; critical thinking; socio-environmental; system design; artificial intelligence; generated pre-trained transformer; education platform

## **Dedication**

This paper is dedicated to neurodivergent individuals everywhere, whose unique perspectives and cognitive processes inspire us to rethink and redesign our educational systems and technologies. May this work contribute to a more inclusive and understanding world that values and nurtures the diverse talents and abilities of all its members.

## **Acknowledgements**

I would like to extend my gratitude to all those who contributed to the successful completion of this research project. Special thanks to Chen & Patten, Dwyer et al., Ellis, Shaw et al., Rodzalan et al., University of Kent & Shaughnessy, Lyerly, and Spector and Ma for their invaluable insights and contributions that enriched my understanding and discussion on the topics of neurodiversity, critical thinking, and the role of artificial intelligence in education. Their research and findings provided a solid foundation upon building this precursor system.

My appreciation also goes to the educators and peers who, through their interactions and feedback, have contributed to designing of an inclusive and accessible learning digital system. Their experiences and challenges have been instrumental in shaping the direction and focus of the project.

Lastly, I acknowledge the limitations faced due to time constraints and the impact it had on conducting extensive user testing. This acknowledgment serves as a reminder of the importance of continued research and development in this field. I am hopeful that this project lays the groundwork for future studies aimed at further exploring how AI can support cognitive modules for creative and critical thinking and bridge socio-environmental gaps for neurodiverse individuals.

Thank you to everyone who played a part in this journey. Your contributions, support, and encouragement have been invaluable.

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## List of Acronyms

ADHD	Attention Deficit Hyperactivity Disorder
AI	Artificial Intelligence
GPT	Generative Pre-training Transformer
LLM	Large Language Models
MVP	Minimal Viable Product

## **Glossary**

**Accessibility:** Refers to the design and implementation of products, services, and environments that are usable by people with a wide range of abilities and disabilities.

**AI (Artificial Intelligence):** A branch of computer science dealing with the simulation of intelligent behavior in computers. AI enables machines to perform tasks that typically require human intelligence, such as learning, problem-solving, and decision-making.

**Artifact:** In the context of this research, an artifact refers to a digital tool or system developed to emulate creative and critical thinking, providing feedback and fostering reflection.

**Critical Thinking:** The ability to analyze information objectively and make a reasoned judgment. It involves the evaluation of sources, such as data, facts, observable phenomena, and research findings.

**GPT (Generative Pre-training Transformer):** A type of artificial intelligence model designed to generate human-like text based on the input it receives. It's part of the larger family of models known as Large Language Models (LLM).

**Iterative Design:** A method of design that involves a cyclic process of prototyping, testing, analyzing, and refining a product or process.

**LLM (Large Language Model):** A type of AI model that uses deep learning techniques to understand, generate, and interact with human language at a large scale.

**MVP (Minimal Viable Product):** The most basic version of a product that can be released to users. The goal of an MVP is to test and validate the core functionalities of the product with the minimum amount of effort and time.

**Neurodivergence:** A term that refers to the diversity of human brains and minds. It encompasses a range of neurocognitive variations, including autism, ADHD, dyslexia, and others, recognizing these as natural variations in the human genome.



Neurodivergent Individuals: People whose brain functions differ from what is considered typical or neurotypical. This includes individuals with autism, ADHD, dyslexia, and other neurocognitive variations.

User Experience (UX): The overall experience of a person using a product such as a website or a computer application, especially in terms of how easy or pleasing it is to use.

Visual Impairments: A term that encompasses all levels of vision loss, including blindness and partial sightedness, which impact an individual's ability to perform daily activities.

# **Chapter 1. Introduction**

Neurodivergent individuals often face socio-environmental and educational challenges. They struggle to fit into the perceived effective model of education which includes social participation and relationships. This barrier is further exacerbated by educators and peers because of misunderstandings or biases, consciously or subconsciously formed by the academic framework, of neurodivergent people (Chen & Patten, 2021). As part of the project, the research focuses on system components that are integral to developing an artifact capable of emulating creative and critical thinking. This artifact aims to provide feedback and foster reflection, addressing the cognitive modules necessary for such tasks. The envisioned artifact is set to become an ecosystem that leverages the capabilities of Artificial Intelligence (AI), Generative Pre-training Transformer (GPT), continuative integrative models, and Large Language Models (LLM). This comprehensive approach aims to harness the strengths of these technologies to research into bridging exclusionary practices and outcasted methodologies that leads to missed opportunities on empowerment, experience, reflection, and reasoning (Shaw et al., 2020).

## **1.1 Goals and Motivation**

The primary goal of this research project is to explore and bridge socio-environmental and educational challenges faced by neurodivergent individuals with Autism. In particular, the cognitive module the project will focus on is feedback and reflection because neurodivergent individuals are often outcasted in group activities (Chen & Patten, 2021). By using AI the project aims to dissect and bridge these cognitive socio gaps which promote creative and critical thinking.

The completion of the minimal viable product (MVP) will provide groundwork for future research which aims to investigate neurodiversity and creative and critical thinking described in Appendix A and B. Due to the limitation of time in the course, it is proposed the research to be conducted following the completion of the product.

The MVP centers around the development of the AI artifact and its controlling platform using a system design approach. The platform will be a web platform that allows document to be uploaded and trained. Educators upon uploading will have the functionality to train small models of their subject matter documents which will assist in the generation of a socio-environmental exercises. A small model in this definition is referred to a be measured by no bigger than 1 gigabyte of texts. These models will integrate with GPT to start conversations through voice or text in the AI companion application. The AI companion application will connect with the conversation data and provide feedback to become the catalyst to reflection for the learner.

Creswell describes a transformative worldview as research that “needs to be intertwined with politics and a political change agenda to confront social oppression” (Creswell & Creswell, n.d.). My motivation to this research comes from many years of observation in post-secondary institution while participating in accessibility and inclusive education applied projects. From my own years of instructional experience, many systems, and frameworks already ingrained in place affect educators and students to contribute to oppressive exclusionary practices directly and indirectly. This research hopes to transform the present academic framework, as well as social interactions, by bringing awareness and finding opportunities to bridge gaps to these cognitive barriers to educators and peers interacting with neurodivergent individuals.

## Chapter 2. Objectives

### 2.1 Overview

This research project explores different Application Programming Interfaces (APIs) such as lang chain and llama index for transforming subject matter documentation data, including socio-environmental activities, into learning activities and conversation. Upon the support, the project will use LLM and transformers such as GPT to facilitate iterative data communications, which can generate ongoing dialogues. Given the time constraints and scope within the academic context, the project will develop through continuous integration and usability considerations using literature reviews and colleague support. This project will explore the technical feasibility and potentials of an AI companion app which conducts conversations through https communications in a physical attachment. Future research initiatives are described in appendices.

### 2.2 Estimated Timelines

Week #	Description
1	Proposal Review and Feedback Research on ethics and obstacles
2	Discover mediums to implement technology
3	Program a platform / app to allow modules of class activities to be inputted
4	Continue software development, train, and test the trained model with NLP libraries to get a friendly child relatable conversation

5	Research on applied medium (potentially 3D printed) and gather feedback from stakeholders
6	Debug, and continue executing the application
7	Continue iterating on software development and testing
8	Complete the first iteration of a functional MVP
9	Continue finalizing the product, debugging, and start documentation
10	More testing and documentation, continue finessing the product and platform
11	More testing and reiterating

## **Chapter 3. Related Work**

### **3.1 Disclaimer**

While there is a growing body of research exploring neurodivergence and AI applications for disability, there are not many studies investigating the intersection of critical thinking and artificial intelligence in the context of neurodivergence. Consequently, much of the related work referenced in this research will pertain to broader themes—namely, critical thinking, education for neurodivergent individuals, and the utilization of artificial intelligence for disability support.

### **3.2 Neurodiversity**

Neurodiversity is a term that's used to describe a multitude of neurocognitive developmental variations, such as autism, ADHD, dyslexia, and others. Coined initially by the Autism community, it challenges stigmatizing connotations often associated with these neurocognitive conditions (Doyle, 2020). Primarily, the "disorder" model in neurodevelopment tends to aim at reducing or curing symptoms that cause significant impairment to daily life activities. This model focuses on behavioral deviations from what is considered the "normal" majority, often marginalizing, or ignoring the unique strengths, and talents (Norbury & Sparks, 2013). The model inherently focuses more on what individuals can't do, compared to their neurotypical peers, rather than valuing their differing cognitive processes and abilities such as cognition in experience-based knowledge (Winters, 2012). Neurodiversity seeks to change this perspective, positioning itself as an inclusive term that builds a framework to give more attention to an individual's abilities. It propounds the idea that all variants of human neurologic function should be respected as just another way of life. It amplifies the strengths associated with neurodivergence, such as innovative thinking, creativity, enhanced pattern recognition, and unique problem-solving skills (Dunn et al., 2023).

### **3.3 Barriers and Discrimination**

Often, neurodivergent individuals struggle to fit into the perceived effective model of education which includes social participation and relationships to both academic social peers and environments. This includes interactions with teachers, staff, and peers, which constructs the education environment. Their deficit in awareness and intervention strategies bars support to neurodivergent students (Chen & Patten, 2021). Misunderstandings of differences as peers may exclude or marginalize neurodivergent students.

Many schools lack comprehensive practices and policies to foster an inclusive learning environment. It becomes increasingly difficult for neurodivergent students to navigate the negative societal stigmatization on any deviations from "normal" cognitive function. Neurodivergent individuals have from voicing their needs or expressing themselves fully to achieve their education potential (Dwyer et al., 2022). Discrimination also exists in the form of standardized testing, which often unfairly disadvantages neurodivergent students by not accommodating their unique ways of processing and understanding information. The widespread tendency to view and portray cognitive function as a linear spectrum instead of a complex model often fails to acknowledge the diverse ways in which the brain can function and excel, effectively limiting the appreciation of neurodivergent abilities (Ellis, 2023).

### **3.4 Critical Thinking**

Critical thinking refers to the ability to conceptualize, apply, analyze, synthesize, and evaluate information gathered from observation, experience, reflection, reasoning, or communication (Shaw et al., 2020). A vital aspect of critical thinking involves seeking and analyzing creative approaches, both individually and within peer groups. Seeing different patterns from various peer feedback forms an essential part to ascertain diverse viewpoints, fostering innovation, and creative problem-solving (Rodzalan et al., 2020).

Receiving suggestions relating to the difficulty of tasks and their practical application aids learners in gauging their understanding and knowledge application (Shaw et al., 2020). Critical thinking is rooted in the ability to search for information,

comprehend its relevance and context, and evaluate its credibility and reliability. This process encompasses the synthesis of information across sources and drawing reasoned conclusions.

It is important to note the underrepresentation of neurodivergent individuals in the process of critical thinking. They are often barred from access to diverse feedbacks and reflections due to discriminative practices in the current education system (University of Kent & Shaughnessy, 2022). This lack of diverse cognitive input undermines the depth and breadth of critical thinking, thereby reinforcing the need for more inclusive and adaptive approaches.

### **3.5 GPT as an assistant**

Loose terminology queries, primarily associated with artificial intelligence systems like GPT, can play a key role in assisting neurodivergent individuals in optimizing their learning process. The system uses LLM to receive and generate human readable patterns (Lyerly, 2023). These systems can provide creative alternative feedback and patterns to a critical thinking problem. By inputting loose term queries into such systems, the responses generated can stimulate unique problem-solving reflection and responses which can potentially nurture creativity and enhance critical thinking abilities.

They can also assist in providing alternative views of problems. Often, neurodivergent individuals may perceive and understand problems in a way that may be overlooked by neurotypical students (Chen & Patten, 2021). Once the data is transformed to index vertices, GPT can transform broken bits of vertices from the English language into comprehensible dialogues by identifying the index patterns. These patterns will become alternative unique perspectives. As a result, diverse approaches to problem-solving can be fostered with specific scenarios and subjects.

### **3.6 Other Research in Artificial Intelligence in Relation to Disability and Critical Thinking**



In their paper, "Inquiry and critical thinking skills for the next generation: from artificial intelligence back to human intelligence," Spector and Ma dissect the framework of critical thinking and underscore its significance in shaping cognitive development. They argue that while substantial resources are allocated to artificial intelligence research, there is not enough focus on exploring human intelligence. The article outlines the key elements of critical thinking, identifying potential areas where artificial intelligence falls short. However, the authors stop short of illustrating how AI can be leveraged as a tool to fill the gaps in the framework for critical thinking, leaving a significant area open for further research and exploration (Spector & Ma, 2019).

The study "Exploring creative thinking in graphically mediated synchronous dialogues" explores the theory of using dialogue nodes and models to promote deeper layers of critical and creative thinking. It employs graphical nodes as a machine-learning pattern to find insights on indicators and events, thus shedding light on new observations and perspectives within dialogues. This research further draws numerous connections between critical thinking, learning, communication, and their potential roles with architectural and machine learning elements. Despite these compelling findings, the study does not explore the possibility of leveraging artificial intelligence as agents to enhance these deeper nodes, thereby fostering more profound critical and creative thinking skills. This gap underscores a crucial area for further investigation and potential advancement within this field (Wegerif et al., 2010).

Peter and Laura Smith's "Artificial intelligence and disability: too much promise, yet too little substance?" investigates the relationship between AI and disability through their personal narrative and autoethnographic reflection. While the study demonstrated potential problem-solving through critical thinking frameworks, it did not ground these findings within a specific framework. Essentially, the research is a generalized exploration of the usefulness of AI, rather than an in-depth assessment of whether AI feedback can enhance critical and creative thinking. How AI could directly improve these cognitive skills within the context of neurodivergence remains a largely untouched field of study (Smith & Smith, 2021).

The studies for AI and disability, especially in neurodiversity and critical thinking falls short in further exploration of one item or another. The articles describe different possibilities of visualizing cognition in AI or machine learning as well as AI's role in disability in a breadth manner. The summary of the articles encourages further investigation to this area. This research project aims to provide by starting with creating the MVP.

# Chapter 4. Methodology and Design

## 4.1 Design Process

This project consists of three main components: an AI model training platform, an online learning activity generator application, and an AI speech and text conversation companion application. To ensure a comprehensive and user-centered approach, the research design will follow a system design methodology. This approach starts with research and user stories to understand functionalities create milestones. The proceeds to drafting a weekly timeline to design, iterate, develop, implement, and deploy these applications.

## 4.2 Research

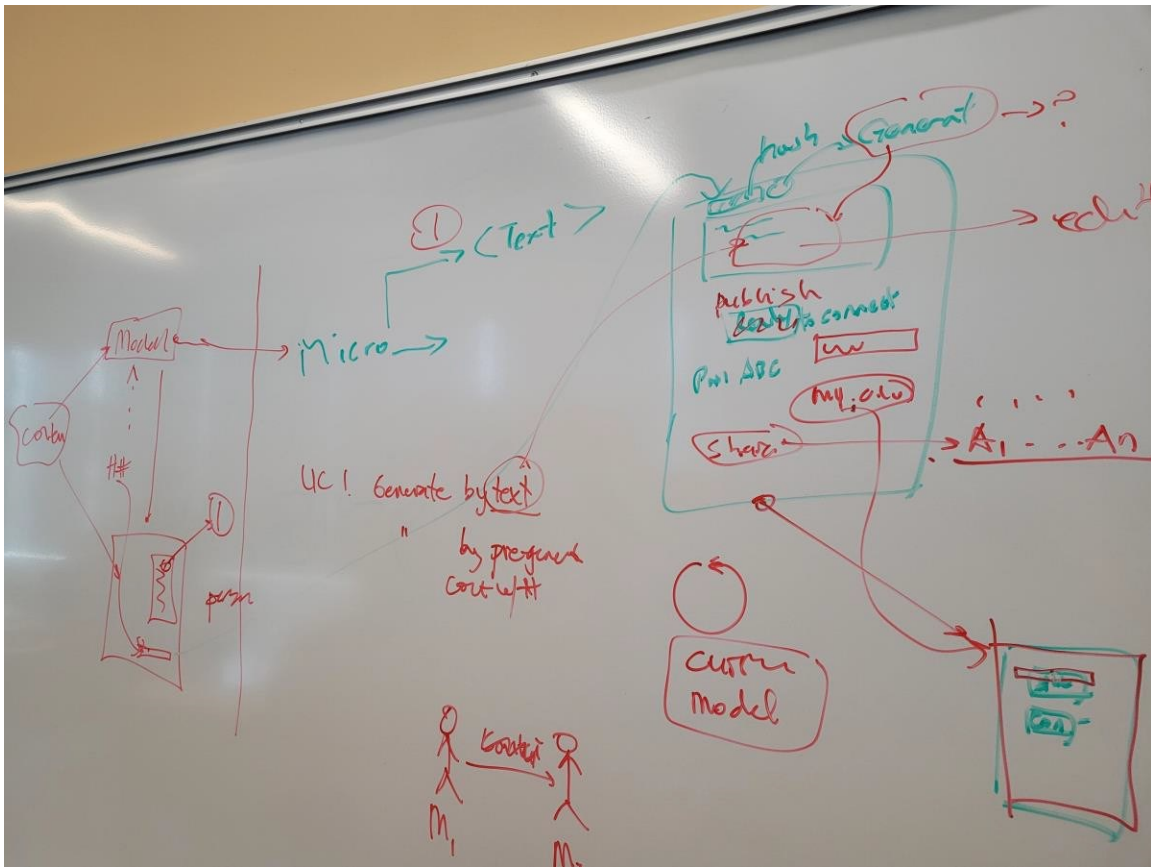


Fig. 1 - Initial draft of all the different AI systems and technology infrastructures and how they integrates with each other

The initial project research as portrayed in Figure 1 focuses on LLM, GPT, and their ability to operate within small models within the scope of a web platform. This hypothesis is that the platform and its correlated services in individual serverless framework containers can utilize the llama index API to transform uploaded documents into vector index embeddings and store them in a cloud storage. This combination can create a sophisticated document matching system through queries and prompts from retrieving the stored embeddings.

The second research focuses on learning to optimize queries and prompts with keywords and patterns to ensure useful and specific outputs from the system. The output needs to be readable in the system architecture which includes the frontend client, server operations, database, and other system modules such as storages and timers. By having this integration, the platform can then focus to design a user friendly and accessible product under technical constraints. This will allow educators to easily upload learning materials, and train models on these materials to allow their students to engage in meaningful, AI supported educational dialogues.

Through the research, conversations with educators and colleagues can be conducted to start user stories which will inspire design and functionalities of the products with the goal to bridge educational gaps, particularly for neurodivergent individuals.

### **4.3 User Stories**

The formation of user stories for this research project began with conversations between educators and their expressed needs for a support system to enhance student learning engagements. These initial discussions highlighted the necessity for a tool that could assist in delivering knowledge and supporting materials socially to students aged 18 or younger. 18 is the derived age in which the learning is still in a public institute. This in particular applies to students who are neurodivergent as they are subject to being outcasted in group activities. As the project's scope and understanding deepened and users finding more use cases, the user stories evolved to focus more on the educators

themselves, seeking functionalities within the system that would empower them to generate and manage their materials tailored to their students' needs.

From these new user stories, a comprehensive set of functionalities and use cases emerged, shaping the development of three distinct systems within the research project. Each system was designed to address specific aspects of the educational support process. This includes material management, content generation, and interaction to feedback and assessment mechanisms. This iterative process of story evolution ensured that the final systems were closely aligned with the needs and challenges faced by educators in supporting their students' socio learning journeys.

### **Original User Stories**

Definition: An educator is a person who teaches and provides knowledge to another person aged 18 or younger in an academic environment.

1. As an educator, I want to be able to easily upload my curriculum activities onto the education platform, so that I can access and share the AI models to my students to link and other educators to view.
2. As an educator, I want to manage and organize curriculum activities with different themes and attributes, so that I can efficiently manage and update my teaching materials.
3. As an education, I prefer a gentle technical learning curve for understanding the platform while I'm using it so that I can access on demand information.
4. As an educator, I want the education platform to have a robust system for tracking and assessing the effectiveness of uploaded curriculum activities, so that I can ensure that the AI conversations align with the targeted learning objectives.
5. As an educator, I would like the education platform to feature a collaborative space where educators can share and curriculum models, providing opportunities for feedback, support, and continuous development.

## **Evolved User Stories**

1. As an educator, I want to easily upload educational content and materials to the platform, so that I can efficiently share knowledge with students aged 18 or younger.
2. As an educator, I need a system that allows me to monitor and evaluate the content, ensuring it aligns with our learning objectives and standards.
3. As an educator, I desire a feature that enables real-time interaction with students with materials I created, allowing it to address their questions and enhance their understanding of the subject matter.
4. As an educator, I seek a platform to help create the entire group activity based on the subject matter. I want information about the time, instructions, and learning outcomes.
5. As an educator, I want to collaborate with other educators on the platform, sharing relevant educational materials.
6. As an educator, I'm looking for a way to integrate interactive and multimedia content into my activities, making lessons more engaging and effective.
7. As a teacher, I aim to utilize the platform's to create and administer quizzes and tests which provides immediate feedback to the students learning.

Weekly sprints and milestones are then derived from these user stories.

### **4.4 Weekly Sprints**

Weekly sprints are conducted to iterate on the design and the implementations. These sprints consist of short, focused milestones to develop drafts, prototypes, and gather feedback from stakeholders. The following milestones are created based on the user stories and projected potential functionalities. This iterative process allows for

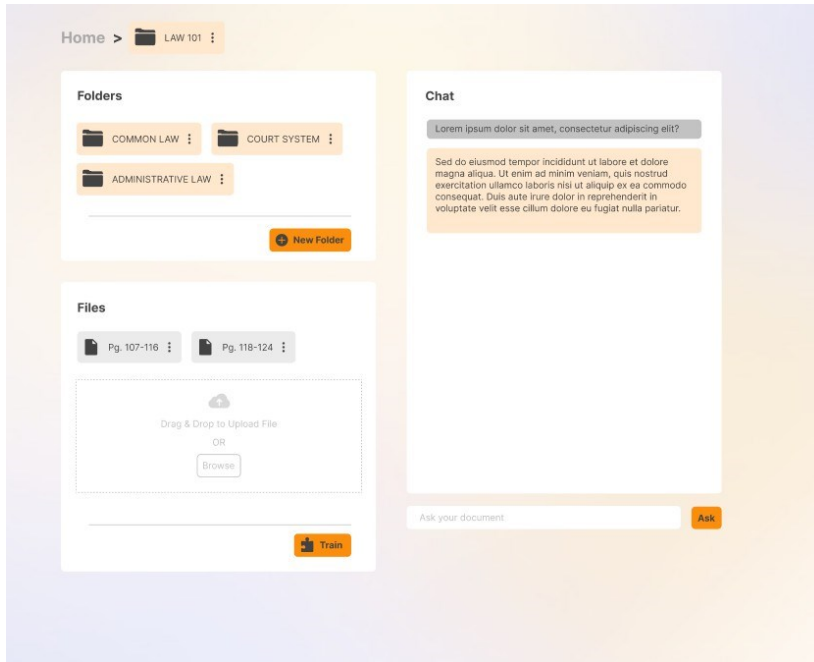
continuous improvement and refinement of the products. A weekly to week timeline was then after estimated in Chapter 2.

### **Milestones**

1. Discovery of problem documentation and transformation to conversation using LLM and small models uploaded by educators.
2. Discovery of the ability to perform continuous conversations within the models itself.
3. Application of the platform with designed interface
4. Test and debug methodology, design, and application with stakeholders.
5. Continuous integration and usability test of a functional viable product
6. Application of the training model platform, the learning activities and the AI companion application to perform contextual conversation.
7. Test, debug, and deploy the system with stakeholders.

### **4.4 Conceptual Design**

The conceptual design of the platform is envisioned as an online digital space where educators can upload learning materials. Then through the content of the material, a companion application will be used for dialogues and conversations.



*Fig. 2 - Figma design of an uploading interface in a familiar organization structure*

At the core of the design is an upload interface equipped with embedding functionality as show in Figure 2. This feature allows for a seamless integration of various types of educational content, including text documents and PDFs, into the platform. Once uploaded, these materials undergo a process to be converted into a format that the companion artifact can interact with, enabling it to understand and converse about the content.





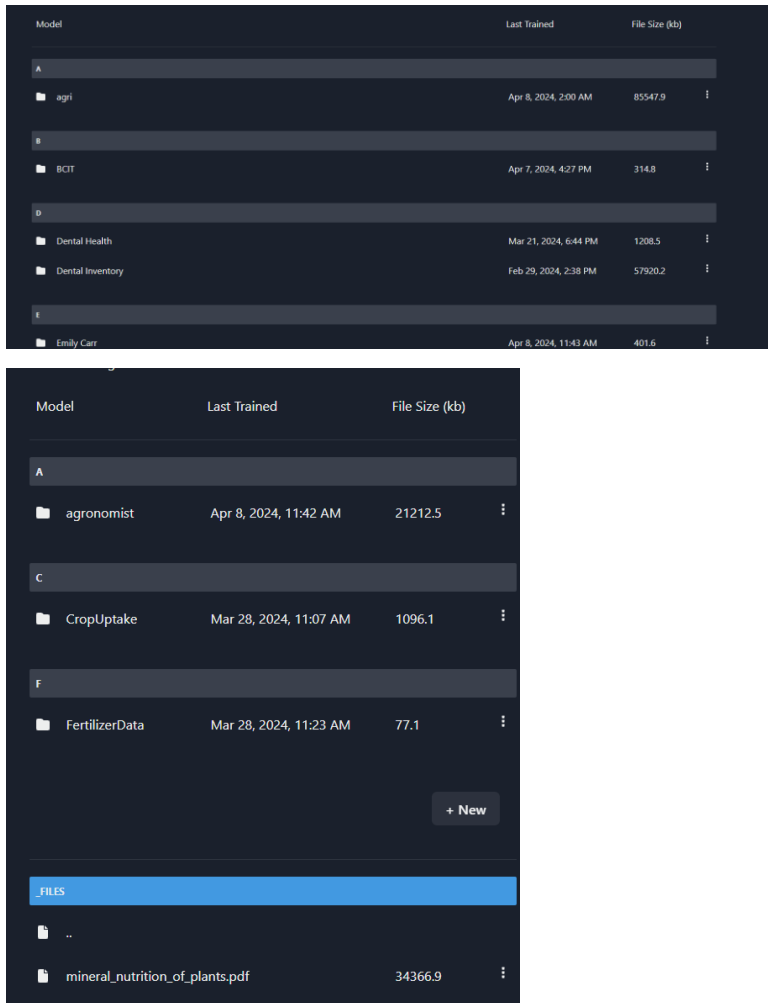
*Fig. 3 - Figma design of the files and folders components*

To facilitate easy navigation and organization, the platform includes an organization interface that mirrors the familiar structure of folders and files shown in Figure 3. This design choice will make it intuitive for users to find and manage their uploaded materials in a natural digital experience. The interface allows users to categorize their materials into different subjects, topics, or any other system that suits their needs.

The platform also features a dedicated space for embedding tests. This is where educators can test the interaction on how the companion artifact will respond using the

uploaded documents. This space is designed to support the fostering of a deeper understanding of the engagement with the learning materials.

## 4.5 Iterative Design and Changes



The figure consists of two screenshots of a model management interface. The top screenshot shows a table with columns 'Model', 'Last Trained', and 'File Size (kb)'. It lists several folders: 'A', 'agri', 'B', 'BCT', 'D', 'Dental Health', 'Dental Inventory', and 'E', each with its last trained date and file size. The bottom screenshot shows a similar table with folders 'A', 'C', 'F', 'CropUptake', and 'FertilizerData', and a file 'mineral\_nutrition\_of\_plants.pdf'. A '+ New' button is visible in the bottom right of the second screenshot.

Model	Last Trained	File Size (kb)
A		
agri	Apr 8, 2024, 2:00 AM	85547.9
B		
BCT	Apr 7, 2024, 4:27 PM	314.8
D		
Dental Health	Mar 21, 2024, 6:44 PM	1288.5
Dental Inventory	Feb 29, 2024, 2:38 PM	57920.2
E		
Emily Carr	Apr 8, 2024, 11:43 AM	401.6

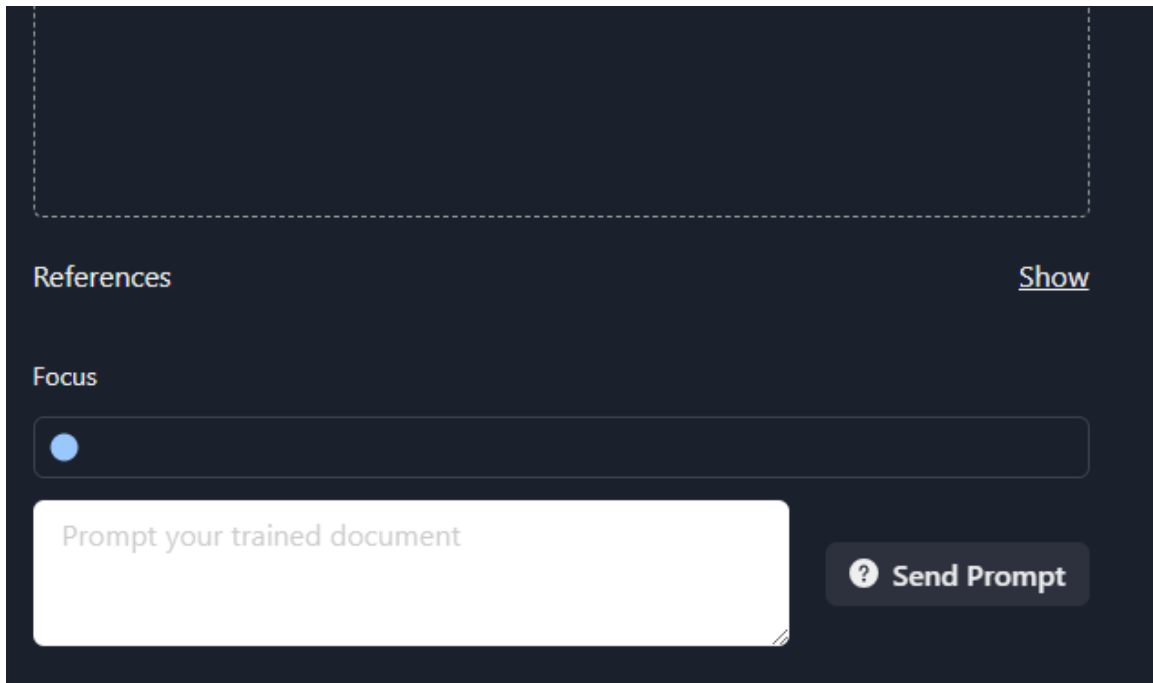
  

Model	Last Trained	File Size (kb)
A		
agronomist	Apr 8, 2024, 11:42 AM	21212.5
C		
CropUptake	Mar 28, 2024, 11:07 AM	1096.1
F		
FertilizerData	Mar 28, 2024, 11:23 AM	77.1
+ New		
_FILES		
--		
mineral_nutrition_of_plants.pdf		34366.9

*Fig. 4 - Folder and file structures and their model stats*

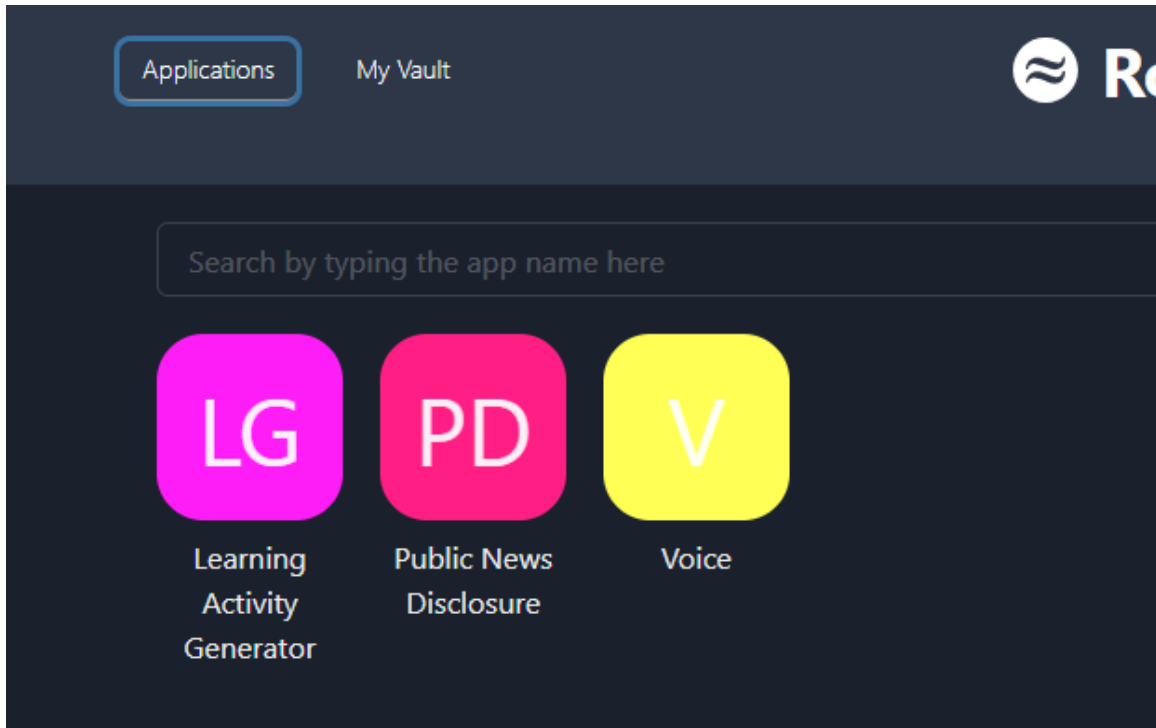
The iterative design and changes made to the system is focused on enhancing the user experience and the functionality of the AI artifact, particularly in how it manages and interacts with uploaded documents. The latest design was refined to better utilize the structure of files and folders, allowing the system to reflect the status of the embeddings more accurately as shown in Figure 4. This adjustment meant that the educators could

more effectively understand and organize the data of their content, making it easier for them to navigate the different functionalities of the platform.



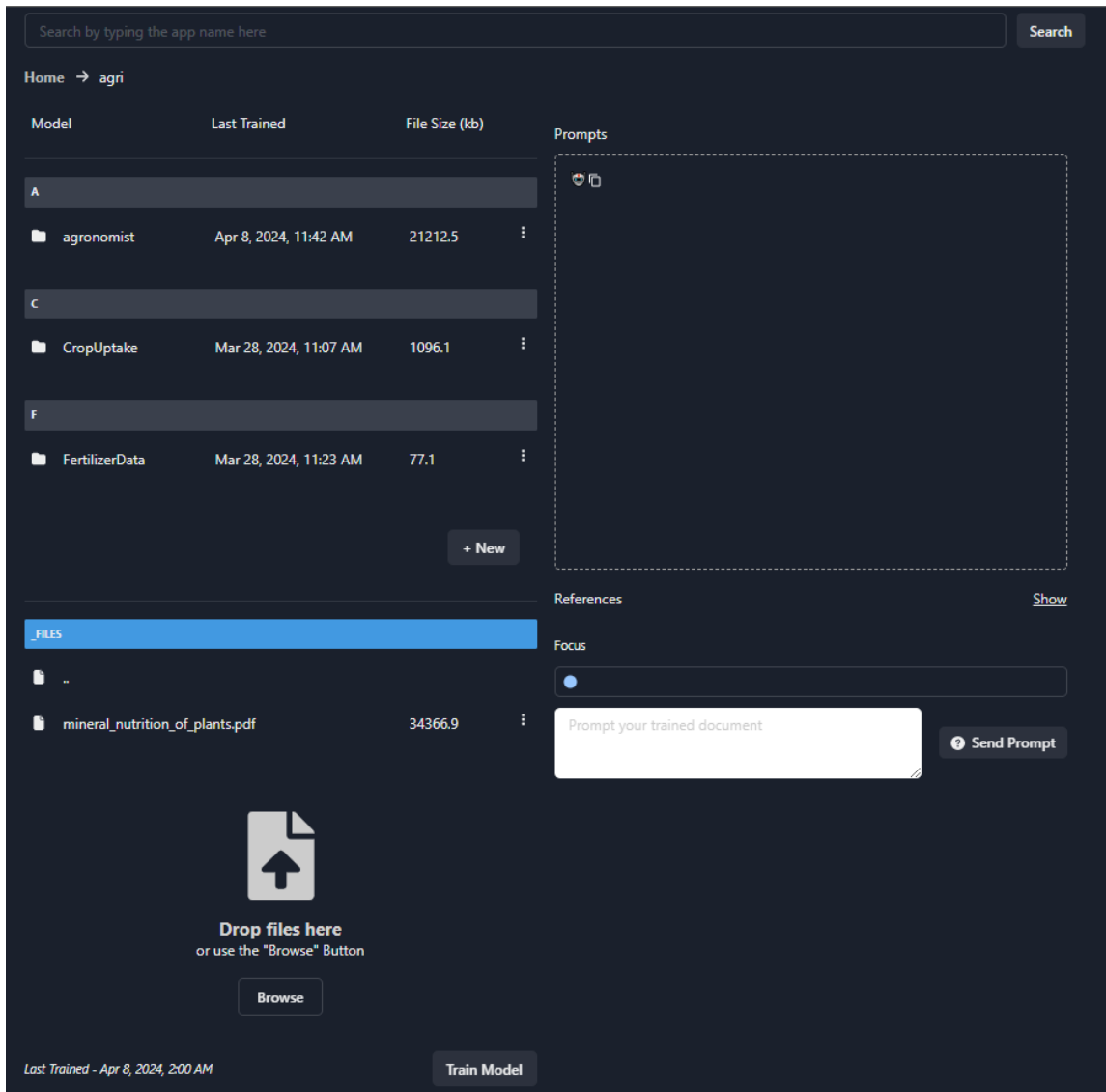
*Fig. 5 - Focus or Broad prompts*

Improvements were also made to understand the functionalities related to prompts and queries. This includes the ability to adjust for focused or broad searches to teach users how to tailor their output needs with the AI to be as specific or as general as need shown in Figure 5. The system's ability to handle queries was significantly strengthened, moving beyond simple conversational exchanges to support complex, multi-nodal trained input and output relations. This advancement allowed for a more nuanced and complex interaction between the different AI models, enabling the system to provide more relevant and relational responses.



*Fig. 6 - Companion applications developed to support specific tasks and solve pain points*

To further refine the user experience for different complexity needs, companion applications were developed with a focus on leveraging the capabilities of multiple embedded documents and their relationships as shown in Figure 6. One such application request was the learning activity generator because educator sought to use the system to help alleviate the pain point of relating subject matter to activities. By building companion applications, users who are not technical can focus on materials and subject matters rather than attempting to integrate all functionalities into a single, potentially overwhelming interface.



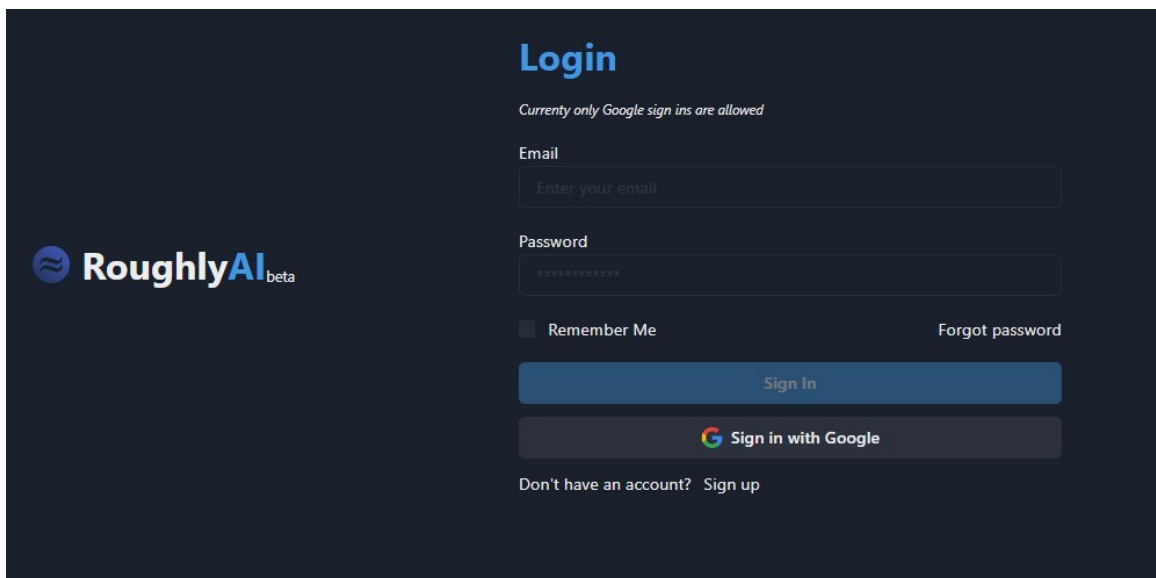
*Fig. 7 - Overall accessibility design changes to contrast, visuals, and architecture*

Accessibility was another key area of improvement, with changes made to enhance the visual aspects of the system, such as colors contrast, simplified functionalities, and information architecture shown in Figure 7. These adjustments were designed to make the system more user-friendly and accessible to a wider range of users, including those with visual impairments or other accessibility needs.

## 4.5 Implementation

The implementation of the educational platform and its companion applications leverages a combination of AI technologies, cloud infrastructures, and modern frontend frameworks. The core of the AI system utilizes the llama index for embedding and querying documents, providing a robust foundation for processing small data models such as education contents with LLM. Currently, the system uses GPT models for these tasks. However, for enhanced security and to leverage the benefits of community-driven development, there is a plan to transition to open-source libraries.

To accommodate the scalability and flexibility of document embeddings, Docker containers and serverless frameworks are employed. These technologies allow for scaling of the embedding and querying processes, ensuring that the system can handle varying loads without compromising performance. The storage of embeddings, documentation, responses, statistics, and metrics is managed through Amazon Web Services' (AWS) Simple Storage Service (S3), offering reliable and secure data storage solutions.



*Fig. 8 - Google OAuth to manage ownership*

User identification and data ownership are critical components of the platform, addressed through the integration of Postgres for database management and Google OAuth for authentication shown in Figure 8. This combination ensures that users can securely access their data while maintaining control over their information.

Data security is further enhanced using cryptographic signatures and hashes. This approach ensures that data shared across the platform is protected against unauthorized access and tampering, providing a secure environment for users to interact with the system.

The platform's interaction features are powered by Mozilla's speech synthesis utilizing its text-to-speech and speech-to-text APIs. These technologies enable the system to engage in conversations with users, making the learning experience more interactive and accessible.

The development and deployment of the main platform and its companion applications frontend interfaces uses NextJS deployed through AWS Amplify. This combination allows for the rapid development of web applications that are both performant and scalable, ensuring that the platform can be accessed by a wide audience.

Language and speech within the platform and companion use the Mozilla and Google language systems. With these technologies, the system can understand and respond in multiple languages, making the platform more inclusive and accessible to a global audience. The dialogue system leverages both learning activity and knowledge base embeddings to engage users in meaningful and in-depth conversations.

# Chapter 5. System Descriptions

## 5.1 Training Model Platform

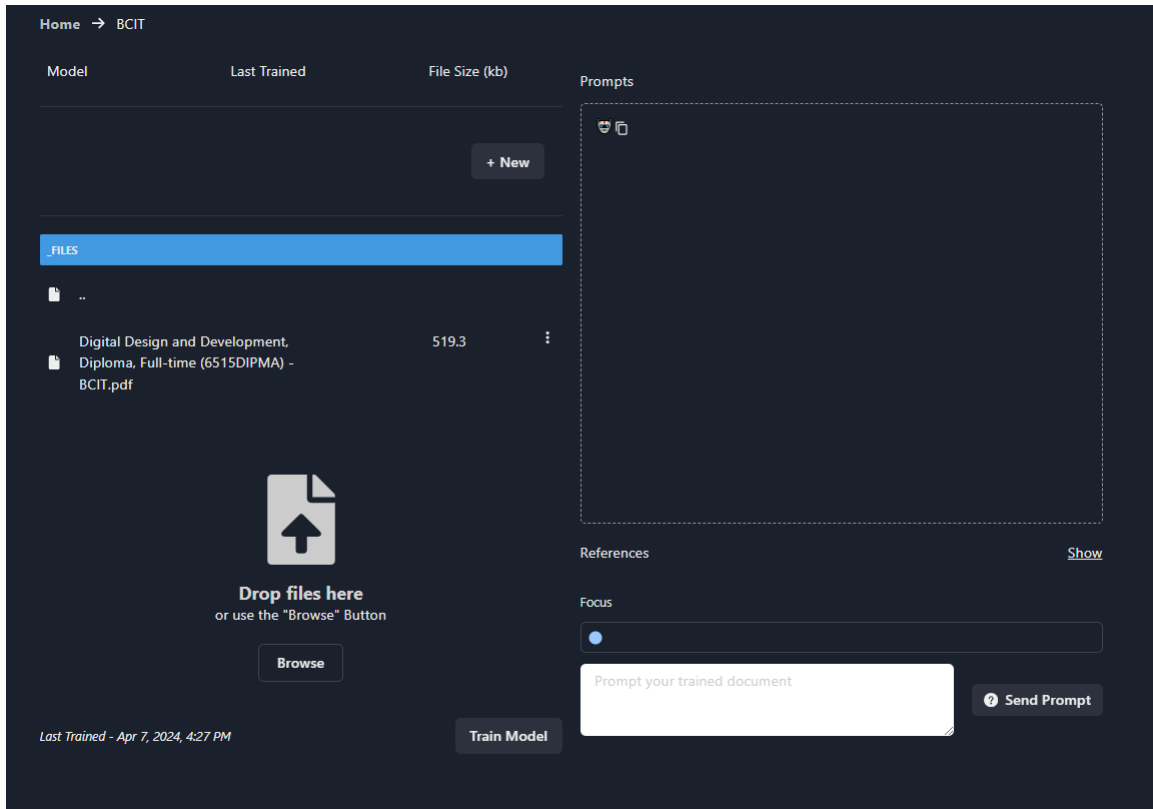


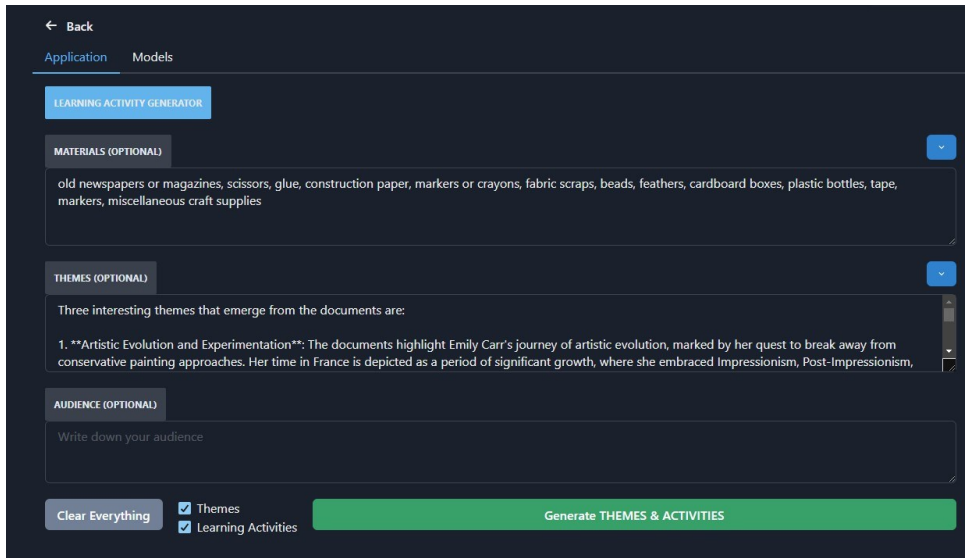
Fig. 9 – Training Model Platform

The online training model platform is a system which enable educators to upload subject matter materials in an array of text formats, including PDF and Word documents. Once uploaded, the platform will introduce a training feature which processes the documents into vector indexes so that it can be embedded with LLM.

Once trained, the platform will have the capability to query and prompt the data inside the uploaded documents. This includes creating engaging and dynamic conversations. Moreover, the platform allows user to benchmark and test multiple small models and their inputs and outputs together. For example, users can find relationships between a camping subject matter and sailing subject matter but allowing the platform to converse their outputs and inputs together.



## 5.2 Learning Activity Generator



The screenshot shows the 'Application' tab of the Learning Activity Generator. It features a dark theme with a light blue header bar containing a 'Back' button and 'Application' and 'Models' tabs. Below the header, there are three main sections: 'MATERIALS (OPTIONAL)', 'THEMES (OPTIONAL)', and 'AUDIENCE (OPTIONAL)'. The 'MATERIALS' section contains a list of items: 'old newspapers or magazines, scissors, glue, construction paper, markers or crayons, fabric scraps, beads, feathers, cardboard boxes, plastic bottles, tape, markers, miscellaneous craft supplies'. The 'THEMES' section displays 'Three interesting themes that emerge from the documents are:' followed by a list item: '1. **Artistic Evolution and Experimentation**: The documents highlight Emily Carr's journey of artistic evolution, marked by her quest to break away from conservative painting approaches. Her time in France is depicted as a period of significant growth, where she embraced Impressionism, Post-Impressionism, and Expressionism.' The 'AUDIENCE' section has a placeholder text 'Write down your audience'. At the bottom, there is a 'Clear Everything' button, two checked checkboxes for 'Themes' and 'Learning Activities', and a large green 'Generate THEMES & ACTIVITIES' button.

*Fig. 10 – Learning Activity Generator*

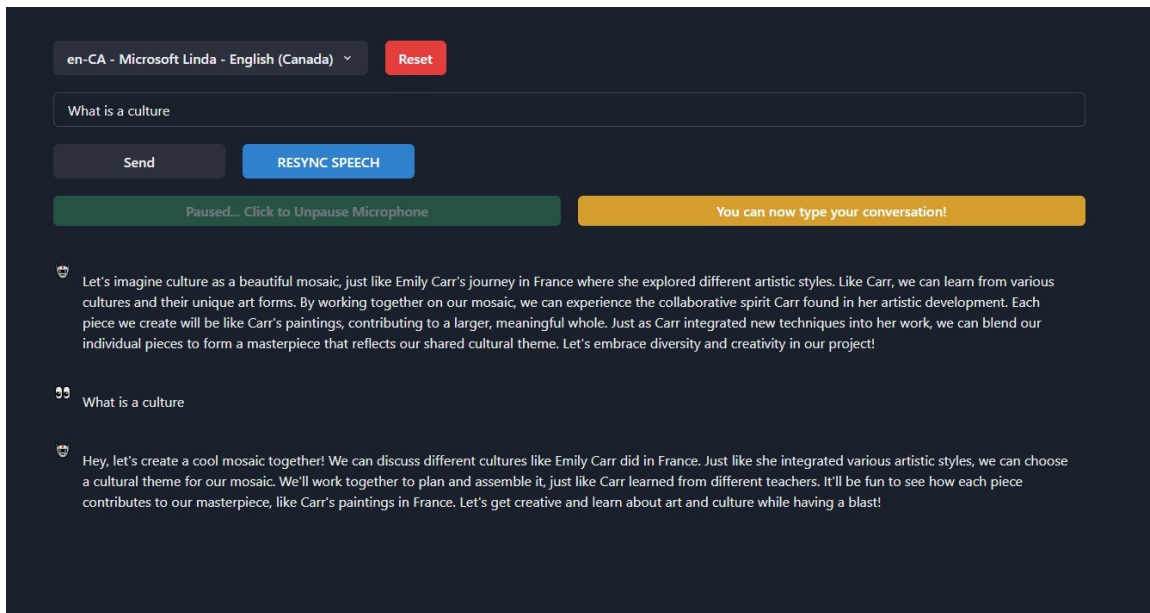
The Learning Activity Generator is an application designed to alleviate the pain point educators have when trying to create activities from a subject matter. Educators can focus on subject matter embeddings, and the application can use these embeddings to create engaging and educational social activities. This application extract's themes and concepts from the documents and then combines the relationship of these data into group activities. This process ensures that the learning activities are grounded in subject matter content.

Each generated activity comes with a comprehensive set of details including a title that succinctly captures the essence of the activity, the estimated duration to help educators allocate time effectively, and a list of required materials, ensuring that all necessary resources are prepared in advance. Detailed instructions provide step-by-step guidance on how to conduct the activity, ensuring clarity and ease of implementation. Furthermore, the aspect of collaboration is emphasized, encouraging participants to work together, thereby enhancing social skills and teamwork.

A unique feature of the Learning Activity Generator is its adaptability. It allows for the modification of materials, themes, and audiences, making it a versatile tool that can cater to a wide range of educational settings and age groups.

The inclusion of learning outcomes is a critical component, as it clearly outlines the educational goals of each activity. This not only aids educators in selecting the most appropriate activities for their specific learning objectives but also allows them to measure the effectiveness of the activities in achieving these goals.

### 5.3 AI Companion Application



*Fig. 11 – AI Companion Application*

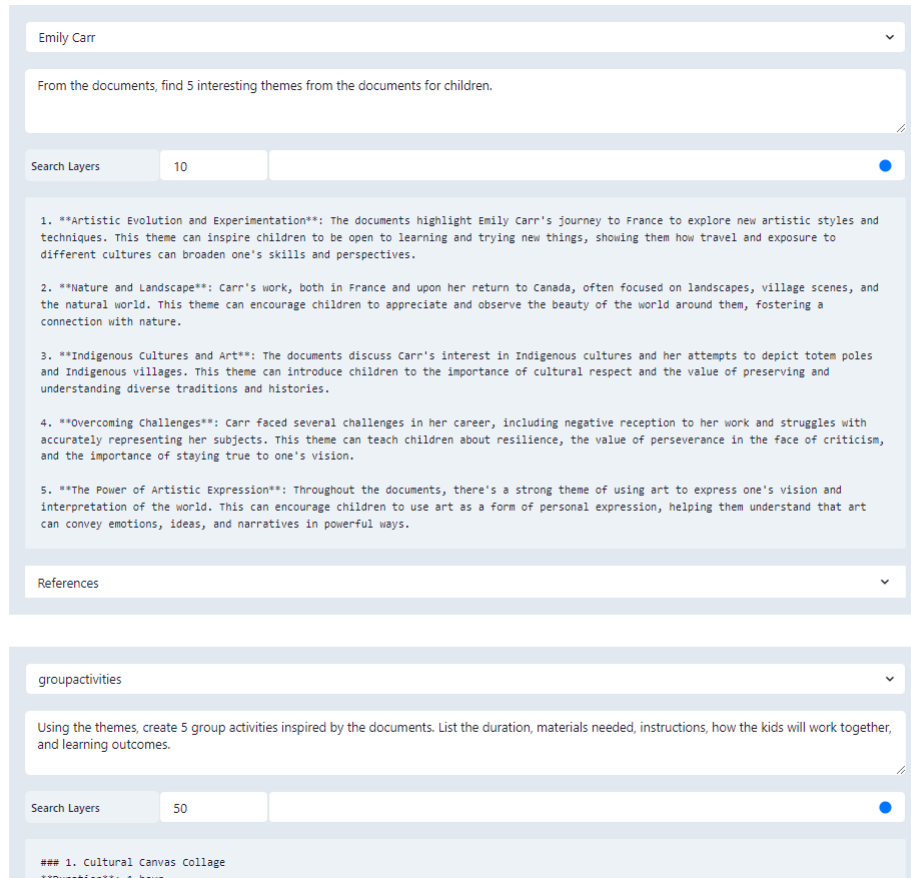
The AI Companion Application is a system that projects voices using trained conversations from the learning activity and the subject matter content. It offers an adjustable voice feature, further customizing the learning experience. Moreover, it will be capable of capturing speech from its learning in multiple languages, allowing it to engage in ongoing, responsive conversation. In its initial stages, the AI Companion Application is intended to start off as a phone application, ensuring it is accessible and easy to use.

The plan for this companion in the future is for it to be affixed to any dolls or toys. This creates an emotionally engaging experience for the user. By being attached to a familiar object, the artifact facilitates a more comforting and personable interaction.

## Chapter 6. Results & Validation

In this chapter, I will show comparisons between ChatGPT and the artifact.

### Trained Document Embedding Results



*Fig. 12 – The ability discern and establish relationships in different small models*

One of the standout results of the training model platform is its ability to discern and establish relationships between various outputs, showcasing its adeptness in handling interconnected data points. It also shows versatility in its operational scope. It can operate with extreme focus on specific details within the documents, or it can broaden its analysis to encompass more general information, depending on the requirements of the query and prompts. This flexibility allows for a wide range of applications, from targeted data extraction to comprehensive document overviews.

Another output result of the platform is its ability to reference and utilize document information effectively. This capability ensures that the extracted data and insights are accurately contextualized, enhancing the reliability and relevance of the outcomes. Its ability to understand, analyze, and reference complex documents opens avenues for many different applications.

## Generated Learning Activities

### Creative Creatures Collage

60 MIN

**MATERIALS**

- old newspapers or magazines
- scissors
- glue
- construction paper
- markers or crayons

**INSTRUCTIONS**

- Choose two letters as the base for your creature.
- Cut out a pile of these letters from the materials provided.
- Arrange the letters on your construction paper to form a creature.
- Glue the letters in place to create your collage.
- Use markers or crayons to add details or background to your creature.
- Give your creature a name and write a short story about its life.

**COLLABORATION**

- Work in small groups to brainstorm creature ideas.
- Share materials and help each other with cutting and arranging letters.
- Present your creature and story to the group, explaining the creative process.

**LEARNING OUTCOME**

- Understanding of artistic experimentation through letter shapes.
- Appreciation for collaborative brainstorming and creation.
- Development of storytelling skills related to artistic work.

Share And Chat

### Cultural Mosaic Masterpiece

90 MIN

**MATERIALS**

- construction paper
- fabric scraps
- beads
- feathers
- glue
- scissors

**INSTRUCTIONS**

- Discuss different cultures and their unique artistic styles.
- As a group, choose a cultural theme for your mosaic.
- Individually, create a piece of the mosaic using the materials provided.
- Combine all pieces to form a large, cohesive mosaic.
- Discuss as a group the meaning behind each piece and how it contributes to the overall theme.

**COLLABORATION**

- Collaborate on choosing a cultural theme.
- Work together to plan the layout of the mosaic.
- Assist each other in the creation of individual pieces.
- Come together to assemble the final masterpiece.

**LEARNING OUTCOME**

- Increased awareness of different cultures and their art.
- Experience in collaborative art creation.
- Understanding of how individual pieces contribute to a larger whole.

Share And Chat

### Innovative Inventions Fair

120 MIN

**MATERIALS**

- cardboard boxes
- plastic bottles
- tape
- scissors
- markers
- miscellaneous craft supplies

**INSTRUCTIONS**

- Brainstorm innovative inventions that could solve everyday problems.
- In small groups, choose one invention idea to develop.
- Use the provided materials to create a model of your invention.
- Prepare a short presentation on how your invention works and its benefits.
- Present your invention to the rest of the group, explaining the problem it solves and how it was inspired by the themes of experimentation and cultural exploration.

**COLLABORATION**

- Work in teams to brainstorm and select an invention idea.
- Divide tasks among team members for building the invention model.
- Collaborate on preparing the presentation.
- Support each other during the presentation phase.

**LEARNING OUTCOME**

- Creativity in solving problems through innovative thinking.
- Teamwork and collaboration in bringing an idea to life.
- Presentation skills in explaining and advocating for their invention.

Share And Chat

Fig. 13 – Comprehensive learning activities with title, duration, materials, instructions, collaboration and learning outcomes

The results from the generated learning activities showcases a comprehensive understanding of the format required for educational activity tasks. This understanding extended to grasping the educational needs, procedures, and the intricate relationships between the subject matter themes and the elements necessary to perform an activity effectively. By integrating these components, the system was capable of not only recognizing the structure of learning activities but also of aligning them with educational objectives and processes.

Furthermore, the system exhibited the ability to translate these activities into productive conversations. This capability suggests that the system can contextualize the educational content within the activities, enabling it to engage in dialogues that are relevant and supportive of the learning objectives. Through these conversations, the system can potentially guide learners through the activity, offering insights, clarifications, and encouragement that are tailored to the educational context of the activity.

### **Dialogue and Conversations**

The dialogue and conversation results from the study indicate a comprehensive understanding on both the specific activities and the subject matter knowledge foundation. This demonstrates the AI's capability to engage in meaningful discussions that encompass a wide range of topics, providing a more contextual learning experience. Furthermore, the conversation has an inherent understanding of the need for collaboration and referencing knowledge, suggesting it can facilitate cooperative learning environments effectively. This is particularly beneficial in educational settings where teamwork and peer interaction are crucial for developing social skills and deeper understanding.

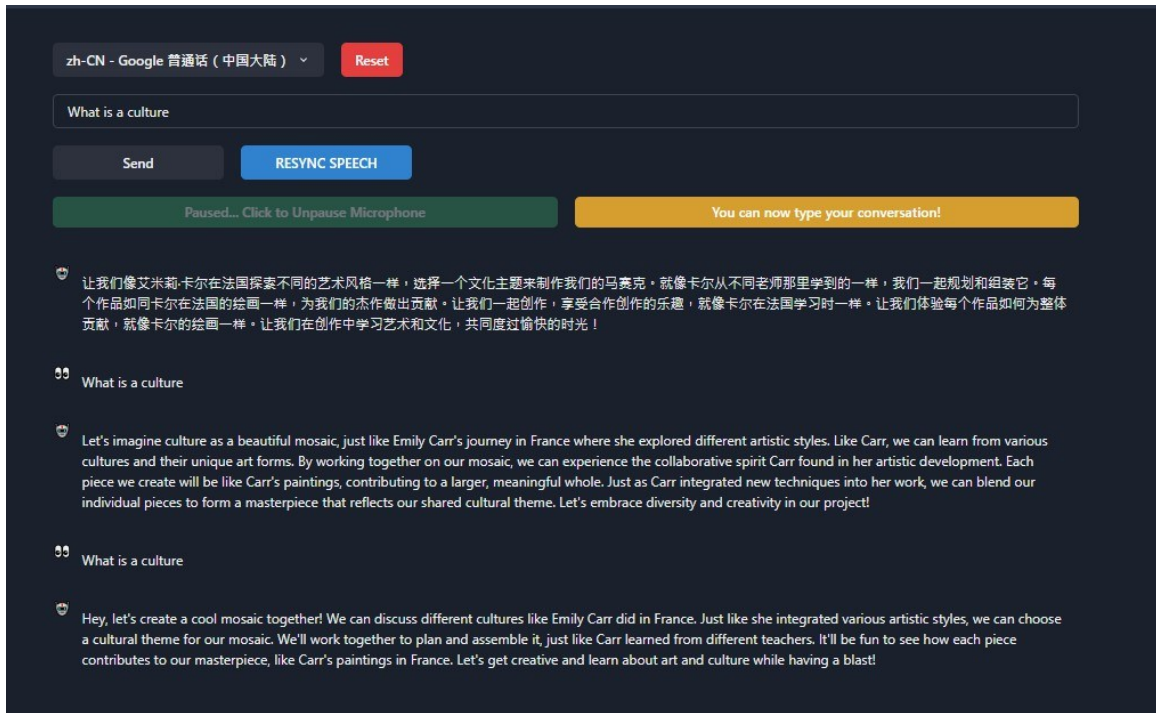


Fig. 14 – multilingual learning and responses in the conversations

The multilingual capacity ensures that the conversations can serve a broader audience, catering to the needs of a diverse group of users, and fostering an inclusive learning environment where every learner could engage fully.

## Validation

To validate the platform’s focus ability and versatility, I conducted a comparison to generate Emily Carr based learning themes in comparison to ChatGPT. I used 3 PDFs which was taken from Emily Carr’s Exhibition Website for the Vancouver Art Gallery. These pdfs focus on Emily Carr’s early life and travels and inspiration.

**For the first prompt I asked ChatGPT to write 5 interesting themes for Emily Carr.**

*Prompt for ChatGPT: Find 5 interesting theme for grade 3 children to learn. (Emily Carr)*

**Then I use the same prompt the public web content for the condensed data in the artifact.**

**<https://vanartgallery.vag.yourcultureconnect.com/e/emily-carr:-a-room-of-her-own>**

*Prompt for Training Model Platform: From the documents, find 5 interesting themes from the documents for children.*

### **ChatGPT**

*For grade 3 children, introducing them to the world of art through the works of Emily Carr can be both educational and inspiring. Here are five interesting themes related to Emily Carr's art that could engage grade 3 students:*

1. ***Nature and Landscapes**: Emily Carr was known for her stunning depictions of Canadian landscapes and nature. Introduce children to the beauty of nature through her paintings of forests, rivers, and mountains. They can learn about different types of trees, animals, and natural features while exploring Carr's artwork.*

2. ***First Nations Culture**: Carr was deeply inspired by the Indigenous cultures of the Pacific Northwest. Explore First Nations art, traditions, and stories depicted in Carr's paintings. This theme can foster an appreciation for cultural diversity and respect for Indigenous peoples.*

3. ***Animal Portraits**: Carr had a special affinity for animals and often featured them in her artwork, including her beloved pet monkey Woo. Children can learn about various animals and their habitats through Carr's paintings. They can also explore concepts such as biodiversity and conservation.*

4. ***Self-Expression through Art**: Carr's unique style and use of vibrant colors reflect her individuality and creativity. Encourage children to express themselves through*



art by experimenting with different techniques and materials inspired by Carr's work. This theme can promote self-confidence and artistic exploration.

5. **Journey of an Artist**: Trace Emily Carr's journey as an artist, from her early years to her later success. Explore her struggles, triumphs, and the development of her artistic style. Children can learn about perseverance, dedication, and the importance of pursuing one's passions.

These themes can be integrated into various learning activities such as art projects, nature walks, storytelling sessions, and discussions about cultural heritage. By exploring Emily Carr's art, grade 3 children can develop a deeper understanding of art, nature, culture, and themselves.

### **Training Model Platform**

1. **Exploring New Places and Cultures**: Children can learn about Emily Carr's journey from Canada to France, her experiences in different cities, and how these travels influenced her art. This theme can inspire curiosity about different cultures and the importance of exploring new places.

2. **The Power of Art to Capture Emotions and Ideas**: Through Carr's reaction to Harry Gibb's art and her own work in France, children can explore how art can express a wide range of emotions and ideas, from joy to shock, and how it can be used to communicate personal visions or interpretations of the world.

3. **Learning from Others**: The theme of mentorship and learning from others is evident in Carr's time spent with artists like John Duncan Fergusson and Frances Hodgkins. This can teach children about the value of learning from others, trying new techniques, and the importance of teachers and mentors in developing skills.

4. **Nature and the Environment**: Carr's work, especially upon her return to Canada, focused on landscapes, Indigenous villages, and totem poles, reflecting her appreciation for the natural world and Indigenous cultures. This theme can encourage

*children to observe and appreciate nature and learn about the significance of preserving cultural and natural heritage.*

5. ***\*\*Overcoming Challenges\*\****: Carr faced many challenges, from the **initial negative reception of her work to the struggle of accurately depicting Indigenous totem poles** while applying her new artistic style. This theme can inspire discussions about perseverance, the importance of staying true to one's vision, and the resilience required to overcome obstacles in pursuit of one's passions.

### **Comparisons**

As highlighted above, my Training Model Platform offers much better condensed subject matter material on the specific themes which is her early life, people she met, France travel, and indigenous inspirations.

## Chapter 7. Conclusion & Discussion

The conclusion of this research project underscores the transformative potential of individually tailored small models and LLM in supporting the socio educational experiences, particularly for neurodivergent individuals and those who find themselves at odds with traditional academic structures. The project's evolution through system design and iterative changes highlights the technical challenges and natures of AI applications in education, revealing how perceptions and utilizations of such technologies evolve with increased understanding and familiarity.

One of the reflections I have from this project is the recognition of the importance of making AI technologies accessible beyond the realms of programmers and data scientists. This democratization of AI tools is crucial for ensuring that the benefits of such technologies can be extended to a broader audience, including educators and students who may not have a background in computer science. By simplifying the interface and interaction with the technologies, the project aims to empower users to harness the capabilities of AI for personalized learning experiences.

However, the project also acknowledges the ongoing challenges related to data security and the potential monopolization of AI technologies. These concerns highlight the need for continued vigilance and the development of robust frameworks to protect user data and ensure equitable access.

Due to academic time constraints, the project faced limitations in conducting extensive user testing, which could have provided deeper insights into the impact to creative and critical thinking among neurodivergent learners. Despite these limitations, the project lays a solid foundation for future research, as outlined in Appendix A and B. This future research will delve into the study of behaviors in which AI can support cognitive modules for creative and critical thinking and explore how AI can bridge socio-environmental gaps for neurodiverse individuals.

In summary, this project represents a step forward in the ongoing journey to leverage AI for educational equity and inclusivity.

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# **Appendix A. Future Research Design and Methodology**

## **APA.1 Design**

The research design centers around a mixed methods approach, utilizing both qualitative and quantitative data to gain a comprehensive understanding of the impact on the learning experiences of neurodivergent individuals.

The qualitative data will involve observing behaviors, traits, and emotions correlated with critical thinking and problem-solving, both with and without the AI artifact. This qualitative assessment aims to codify positive learning traits as well as to detect any resistance or negativity about the opportunities for critical thinking.

The quantitative data, on the other hand, seeks to validate the usage of the AI artifact, alongside tracking the time taken to complete the given tasks. To supplement these methods, the study incorporates in-depth, before-and-after interviews designed to identify positive heuristics and gauge different learning ratings. This includes comfort level, self-confidence, empowerment, interests, understanding of problems, perspectives on proposed solutions, and the feeling of accomplishment.

## **APA.2 Location**

The research will be conducted within primary school classrooms to provide an environment that reflects a typical learning setting.

## **APA.3 Participants**

Participant selection inclusion criteria includes neurodivergent individuals diagnosed with Autism or ADHD, a diverse mix of genders, ages between 6 to 12, and must comprehend the English language. They will be recruited with the assistance of schools and families. This age range represents the age where cognitive development that is logical and abstract thinking happens (“Intellectual and Cognitive Development in Children and Teens,” n.d.). The selection process will be random, to ensure a representative sample. Recruitment efforts will be aided by collaboration with

neurodiversity societies, such as AutismBC, which will lend credibility to the research secure ethical considerations from participants and relevant stakeholders. There are two exclusion criteria. First, participant must not have any medically diagnosed cognitive trauma. Second, participant must not be attending a school for special needs. The study does not want to include outside factors which plays a role to the success or failure of the tasks.

#### **APA.4 Tasks**

Participants will be presented with problems that emulate and roleplay day-to-day scenarios aimed at creating collaborative opportunities involving critical thinking and decision making. These tasks will include well-defined to ill-defined solutions, requiring participants to form rational assessments and evaluations based on provided evidence and arguments. For example, one such task is planning a grocery shopping trip together with friends to prepare dinner.

The problem will present multiple evidence and arguments. Examples of this in the grocery shopping task example includes: the items on sale, cooking requirements, recipe numbers, dietary restrictions, and budget constraints. There will be well-defined solution, such as purchasing the correct items within a limited budget and restrictions. There will be ill-defined solutions such as deciding to cook fewer dishes or overlooking some dietary restrictions because of budget challenges.

Two problems will be presented in an one hour session considering the average productivity time provided by vouchercloud (Ltd, n.d.). In the first 30 minutes, participants will be asked to solve a problem with no AI artifacts. Participants are then given a survey to rate their learning heuristics mentioned in the Design. Then for the remainder of time, participants will be asked to solve another problem but are asked to communicate with the AI artifact to foster feedback and reflections in human-like interactions. The AI artifact will use accessible and personal speech-to-text translations. The goal is to carry out 100 such sessions, subject to available budget and time, to ensure an exhaustive understanding of various neurodivergent creative and critical thinking experiences.



## **Appendix B. Future Methods: Data Collection, Analysis and Interpretation**

### **APB.1 Independent Variables**

The independent variable will be the introduction of the AI artifact. The AI artifact will not be present in the first 30 minutes. It will then be present for 30 minutes as the before survey is completed.

### **APB.2 Dependant Variables**

Participant behavior, traits, and actions will be captured by an observer. Before and after survey data will capture comfort level, self-confidence, empowerment, interests, understanding of problems, perspectives on proposed solutions, and the feeling of accomplishment.

The time taken to comprehend and present a solution to the problem will be captured for both with and without the AI artifact.

### **APB.3 Controlled Variables**

The AI artifact will be prepared with LLM and custom trained lesson modules and NLP to emulate human-like interactions with the intention to provide feedback and reflection instead of answers.

The problems presented will include cooperative day to day scenarios, multiple evidence and arguments, decision making, well-defined to ill-defined solutions.

### **APB.4 Method and Data Collection**

#### **APB.4.1 Codified Insights**

During the research process, there will be one observer taking meticulous notes concerning the participants' behaviors, traits, and actions. These notes will focus on noting both the participants' positive engagement and any instances of resistance or

rejection. These observational data will then be systematically coded by a committee comprising five people differing in their areas of expertise.

These experts include one of neurodivergent, human behaviours, education, psychology, and neuroscience. They will be capturing patterns in participants' interactions with and without the AI artifact, their problem-solving processes, and their reactions to the learning experience.

#### **APB.4.2 Comprehension and Solution**

Participants problem comprehension time and solution time in their duration with and without the AI artifact will be captured. Comprehension time is defined by the number of seconds it takes from listening to the problem to identify the evidence and arguments. Solution time is the time it takes from identifying the evidence and arguments to making a decision that produces a well-defined or ill-defined solution.

#### **APB.4.3 Learning and Heuristic Survey**

A before survey, after the participants complete the first 30 minutes without the AI artifact, will be given to rate their comfort level, self-confidence, empowerment, interests, understanding of problems, perspectives on proposed solutions, and the feeling of accomplishment. The same survey will be given to the participants again after the 30 minutes with the AI artifact.

#### **APB.5 Analysis**

##### **APB.5.1 Codified Insights**

Clustering and grouping of similar behaviors, traits, and actions will establish major themes and categories which will consolidate into creative and critical thinking insights. The identified clusters will be analyzed to indicate both positive and negative elements of the participants' learning experiences with and without the AI artifact.

##### **APB.5.2 Comprehension and Solution**

The assessment of the time taken to comprehend and complete represents the participants' adaption and perception time. By gauging the duration needed to approach and solve these tasks with and without the help of the AI artifact, the research can evaluate the learning elements provided by the AI artifact. Comparisons will be drawn against the completion times of similar tasks.

### **APB.5.3 Learning and Heuristic Survey**

For a comprehensive analysis, a before-and-after survey rating will be collected to measure several variables integral to critical thinking. These variables encompass the understanding of the problem, the reasoning behind each solution, and the participants' comfort level during the process. To capture the emotive impacts of learning, self-confidence, empowerment, interest level, perception of devised solutions, and the overall feelings of accomplishment will also be assessed.

## **APB.6 Interpretation**

### **APB.6.1 Codified Insights**

Through exploring the dichotomies of learning experiences and elements in the codified creative and critical thinking, the research will be able to identify aspects that motivate or discourage neurodivergent individuals in their learning journeys, thereby framing the AI artifact's possibilities to be an enabler to their cognitive development.

### **APB.6.2 Comprehension and Solution**

The correlation between time completions and the effectiveness of creative and critical thinking is central to these analyses. If the introduction of the AI artifact results in significant reductions in completion times along with an evident increase in solution time and the quality of solution, it could be inferred that the AI artifact indeed enhances creative and critical thinking effectiveness among neurodivergent individuals.

### **APB.6.3 Learning and Heuristic Survey**

These survey experience heuristics offer a clear view of the immediate effects of the AI artifact in a learning setting. They provide a comparative and quantifiable means to explore the potential benefits and challenges. If the comparative survey ratings increases after the introduction of an AI artifact, it means the participants also feels emotionally improved and more confident in their creative and critical thinking. It further confirms the importance for an inclusive socio intervention.