

Automating Analysis for Efficient and Effective Learning Solutions

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ABSTRACT

The organizational, audience, performance, learning, and media analyses that undergird the creation of relevant and effective learning solutions require the collection and analysis of a great deal of data. Artificial intelligence offers the ability to more efficiently and effectively collect and analyze that data to optimize and expedite learning solution development.

C² has been researching AI capabilities for processing large datasets from disparate sources to rapidly identify key themes and make recommendations for learning objectives, learning structure, instructional strategies, assessment strategies, timing, and media selection. As part of this research, the C² team is creating and testing prototypes of an AI application that will guide instructional designers and analysts through the analysis process, ensuring they complete all required steps and collect the right data. The AI automates tedious data collection and analysis tasks, while providing frequent opportunities for instructional designers and analysts to review and enhance the output.

This paper will describe the results of C²'s research and prototyping to address the following questions:

- At which points in the analysis process can AI provide the most value?
- Where in the analysis process are instructional designer inputs most needed?
- How should AI prompts be engineered, tested, and revised to provide the most accurate output?
- How can data security and privacy be protected while providing easy access to the widest range of data?
- What outputs can be created to seamlessly integrate with typical learning analysis and design deliverables?

ABOUT THE AUTHORS

Cody Caddell is the Director of Digital Transformation at C² Technologies, Inc., where he leverages advanced Artificial Intelligence (AI) and Machine Learning (ML) technologies to revolutionize the training and simulation industry. With over two decades of experience, Mr. Caddell has been instrumental in transitioning traditional training and educational formats into cutting-edge eLearning platforms. He specializes in automating business processes through Robotic Process Automation (RPA) and intelligent bots, seamlessly integrating digital technologies across business operations to fundamentally alter company dynamics and enhance customer value delivery. He holds a Bachelor's degree in Communications from the University of Oklahoma.

Claudia Escribano is the Director of Creative Learning Solutions at C² Technologies, Inc., where she develops and delivers professional development opportunities for in-house staff and designs and develops leadership development programs for external clients. With 40 years in the learning industry, she has supported a wide range of audiences in a variety of organizations throughout the entire instructional design process. In her current role, she frequently conducts large-scale learning analyses for both government and private sector clients. Seeing the opportunity to apply AI to gather, organize, and analyze large amounts of data, she has been experimenting with integrating AI into her rigorous analysis process. She holds a Bachelor's degree in Chemistry from Georgetown University, as well as a Chief Learning Officer graduate certificate from George Mason University.

Stephen Godwin is a Software Engineer at C² Technologies, Inc, where he plays a pivotal role in designing and implementing innovative technical solutions for educational technology. In addition to developing an automated career pathing tool currently in use by several Federal agencies, he helps manage all aspects of security for multiple servers located in the Azure.gov FedRAMP environment. He is currently leading several projects that integrate AI into educational technology to enhance personalization, efficiency, and effectiveness. He has a Bachelor's degree in computer science, augmented by certifications in key programming languages such as Visual Basic, C++, and Java, which equip him for the innovative demands of educational technology development.

Beth Myers is the Gamification and Immersive Learning Lead at C² Technologies, Inc, where she leads and coordinates C²'s initiatives in gaming and immersive learning with over 7 years of experience designing, developing, and facilitating innovative training solutions in wide-ranging modalities. Her expertise and passion in gaming/gamification have enabled her to bring learning solutions to life in a fun, memorable, and personalized way, ensuring that the user's experience is at the center of the design. With previous experience as an adjunct for an Instructional Game Design Master's course, Beth continues to share her knowledge by speaking at conferences, writing articles, and creating her own learning games. She holds a Bachelor's degree in Music and a Master's degree in Instructional Technology from Bloomsburg University.

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INTRODUCTION

The advent of Artificial Intelligence (AI) in instructional systems design and courseware development has brought about a paradigm shift, transforming how educational content is created, customized, and disseminated (Compton, 2023). For instructional designers (ISDs), AI has emerged as a powerful ally, automating tasks and enabling a focus on more complex, creative aspects of course design. AI's data processing capabilities offer invaluable insights into learner behaviors and outcomes, fostering a more evidence-based approach to educational design. (Roldan, 2024).

Instructional systems design analysis is both a rigorous science and an art that relies on the instructional designer/analyst's experience and expertise.

This paper describes development of an AI-enabled tool for learning analysis that combines the analytical rigor of AI with the art of an effective instructional designer (Berretta et al, 2023). This tool provides consistency in the analysis process and rapidly analyzes large quantities of data to provide key findings and recommendations. The instructional designers provide unique inputs that only they can provide based on their in-depth knowledge of the organization, the target audience, and the job. In addition, they review the outputs at various stages throughout the analysis process, adjusting them to reflect nuances that only humans may be able to detect and bringing in subject matter experts (SMEs) and stakeholders to validate the outputs' accuracy. These checkpoints ensure that the data entered at each stage of the analysis process is as accurate as possible.

While the current focus is on learning analysis, this tool will ultimately support all aspects of Analysis, Design, Develop, Implement, Evaluate (ADDIE) (Stefaniak, 2020), which will help to ensure development of learning solutions that are grounded in and remain connected to analysis findings.

THE AUTOMATED ANALYSIS PROCESS

Developing effective learning solutions requires a comprehensive view of all the factors that affect job performance, including the organizational context, the characteristics and needs of the target audience, and the specific tasks and competencies that ultimately support the organization's mission (Figure 1).

Beginning with a clear vision of the desired end result and employing a systematic logic model ensures each learning module is aligned with the organization's overall mission (Kneale, Thomas, & Harris, 2015) (Shakman and Rodriguez, 2015).

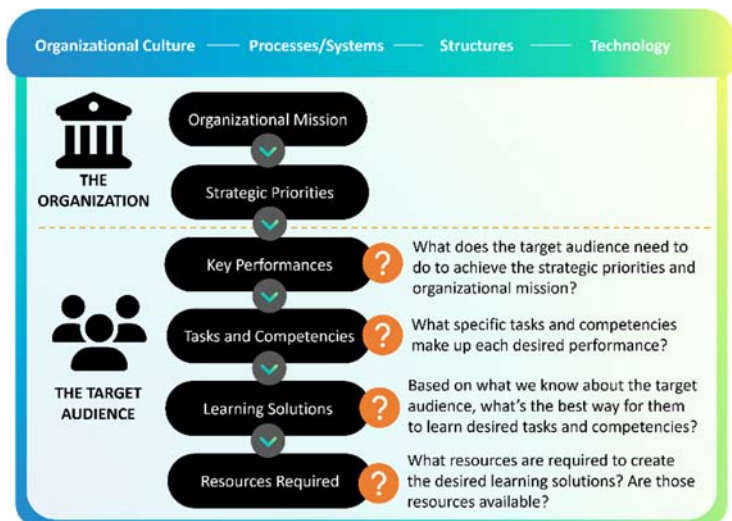


Figure 1. A Holistic View of Analysis

This analysis requires robust data related to the organization and its culture, the target audience, and the desired performance.

The Analysis module of the ADDIEMate tool incorporates and synthesizes all of these analyses: organizational, audience, task, learning, and media selection. While it guides instructional designers through all the steps of a comprehensive analysis, it provides the flexibility to begin the analysis at the most appropriate starting point. For example, if organizational and target audience analyses have already been completed, those outputs can be uploaded, and the instructional designer can start with the task analysis.

Each analysis incorporates AI data analysis followed by required instructional designer actions to review and modify the AI outputs.

SETUP

Upon launching ADDIEMate, users can determine whether to start a new project in the analysis phase or return to an existing project. While each analysis is set up as a unique project, with its data contained in its own secure environment, users can port data between projects. The person who creates the project is the project owner. They can then assign others to the project with specific user levels that provide rights to view, edit, and approve.

Launching a New Analysis

If users start a new project and choose to begin in the analysis phase, they must first enter some basic information to set up the analysis record (Figure 2). They then continue by completing actions to conduct both data collection and data analysis activities, which are also accessible from the Analysis option in the left menu.

Figure 2. Launching a New Analysis

DATA COLLECTION

The first step in the analysis process is for Instructional Designers to assemble the data that will be used for the analysis. Instructional designers initiate data collection by uploading data to ADDIEMate, including interview and focus groups notes, survey data, observations, stakeholder guidance, relevant articles, links to relevant web sites, and any other artifacts. In this way, instructional designers control the data that is analyzed, thus ensuring high data quality and relevance and addressing biases (Roldan, 2024). As described later in this paper, additional control is incorporated into each analysis by allowing users to select the specific data items to analyze.

If users require more guidance on what data to collect, Robotic Process Automation (RPA) technology walks them through a series of questions to generate suggestions for collecting data, including available resources online. Users can then review these suggestions with clients and make a plan for gathering the data.

Once the data has been uploaded, users select the analyses they want to conduct from the left menu. The specifics of these analyses are covered in the following sections.

ORGANIZATIONAL ANALYSIS

The purpose of the organizational analysis is to 1) ensure that any learning solutions developed align with and support the organization's goals and 2) identify the organizational context in which the target audience operates.

This analysis connects target audience behaviors to the success of the organization. In addition, it identifies organizational constructs that may encourage or inhibit desired behaviors. It also identifies limitations that learning designers may need to address. For example, if learners work in a high-stress, high-tempo environment, there may not be a lot of time set aside for learning, or if the client lacks a robust technological infrastructure, designers may not be able to implement high-tech learning solutions.

This analysis may be skipped for the current project if it was previously completed. In that case, instructional designers will upload the outputs of the previously completed organizational analysis to use as inputs to their task and learning analyses. If multiple new projects connect to the same organization, pieces of the analysis may be ported in and reused when a new project is started.

The organizational analysis consists of the following steps as described in the following subsections: 1) user selection of data to analyze, 2) AI analysis, 3) ISD review of AI outputs, and 4) export to a Word document.

AI Analysis

The AI analysis occurs by applying carefully engineered prompts to user-selected inputs to generate the desired outputs as shown in Table 1. The prompts for each stage of analysis were developed by applying best practices in prompt engineering (Lo, 2023) (OpenAI, 2024). The prompts are structured to first provide the context and framework for the analysis and then to ask specific questions, identifying desired outputs and formats. Through multiple iterations of testing and checking outputs against human-generated results, the prompts were refined to yield the most accurate results.

Key elements of the prompts used are shown in the table below.

Table 1. AI Organizational Analysis

Inputs	Prompt Key Elements	Outputs
User selected <ul style="list-style-type: none"> • All or a portion of uploaded data • Data from other analyses, if appropriate • Internet data, if desired 	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis • The data to analyze • Type of analysis to perform • Desired output and format • Confidence rating of the accuracy and relevance of the outputs • Follow-up prompts to focus on: <ul style="list-style-type: none"> ○ Organizational structures ○ Processes and systems ○ Organizational culture 	<ul style="list-style-type: none"> • An organizational assessment that describes the organizational environment and culture • A list of organizational structures, processes, and systems that support desired behaviors • A list of organizational structures, processes, and systems that inhibit desired behaviors • The organizational mission • The organization’s strategic priorities

ISD Actions

Each time an AI analysis is run, its outputs are presented to the instructional designer for review and fine-tuning. The instructional designer evaluates the AI outputs and updates them based on their personal knowledge of the client and the organization. They may also share these outputs to gain the unique perspectives and feedback of client stakeholders and SMEs. When they have completed these activities, they save the updated analysis outputs, which then become inputs for other analyses.

Several report options allow users to send the analysis outputs to a formatted Word document, which can be saved, edited, shared, and printed. These reporting features allow instructional designers to quickly assemble a comprehensive Analysis Report, as well as smaller segments of it, such as an Organizational Analysis Report.

AUDIENCE ANALYSIS

ADDIEMate’s audience analysis is based on a user-centered design approach that results in user personas depicting target audiences’ key characteristics, challenges, motivators, learning needs, preferences, and perspectives on the learning topic. These user personas help guide learning design tailored to the unique needs of each target audience.

If an audience analysis has already been completed, users can skip this analysis and instead select from existing target audience personas as inputs to their task and learning analyses.

This analysis consists of the following steps as described in the following subsections: 1) user selection of data to analyze, 2) AI analysis, 3) ISD review of AI outputs, and 4) export to a Word document.

AI Analysis

Table 2 shows the inputs, key elements included in the prompts, and outputs of this audience analysis.

Table 2. AI Audience Analysis

Inputs	Prompt Key Elements	Outputs
User selected <ul style="list-style-type: none"> • The outputs of the organizational analysis • The library of uploaded data – either all of it or selected items • Data from other related analyses • Publicly available data on the internet 	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis • The data to analyze • Type of analysis to perform • Desired output and format, specifying what should be included in the user persona, both textual and visual • Confidence rating of the accuracy and relevance of the outputs 	<ul style="list-style-type: none"> • User persona(s), including visual(s) to represent the target audience(s) • Brief description of the target audience’s perspectives on the learning topic

ISD Actions

Instructional designers review the generated AI outputs and

- Update as desired
- Share with stakeholders and SMEs
- Save changes
- Export to a Word template to edit, save, print, and submit as a deliverable

TASK ANALYSIS

Grounded in an in-depth understanding of the organization and the target audience, the instructional designer can begin the task analysis, which involves identifying the key performances the target audience needs to complete to achieve the organization’s strategic priorities and mission. Incorporating the organizational and audience analyses into the task analysis ensures that recommended learning solutions are relevant to the target audience in the organizational context and impactful in achieving organizational goals.

After user selection of the data to analyze, this analysis involves two rounds of AI analysis and instructional designer review. As with previous analyses, the results can be exported to a Word document for printing and submitting for client deliverables.

AI Task Analysis #1

The inputs, key elements of the prompts, and outputs for the first AI analysis are shown in Table 3.

Table 3. AI Task Analysis #1

Inputs	Prompt Key Elements	Outputs
<p>User selected:</p> <ul style="list-style-type: none"> • The outputs of the organizational analysis • The outputs of the audience analysis • The library of uploaded data – either all of it or selected items • Data from other related analyses • Publicly available data on the internet, if desired <p>User identifies:</p> <ul style="list-style-type: none"> • Specific strategic priority(ies) to support • Specific target audience to support • Key performance required 	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis, and the applicable part to use • The data to analyze • Type of analysis to perform • Connection to other analyses, including organizational and audience, specifically the organization’s mission and strategic priorities • Criteria for determining what is a key performance and what is not • Desired output and format, including categorization of tasks • Confidence rating of the accuracy and relevance of the outputs 	<ul style="list-style-type: none"> • List of key job tasks for achieving the strategic priorities, with each task categorized by its type, whether a collective or individual activity

ISD Actions

The instructional designer then reviews the list of job tasks and modifies it as they see fit. They may include client stakeholders and SMEs in conducting this review. Once the task list is complete and accurate, the ISD initiates an analysis to define each task in more detail. Based on data related to the frequency, importance, and difficulty of each task, the ADDIEMate analysis tool can make a Train/No Train decision.

AI Task Analysis #2

The inputs, key elements of the prompts, and outputs for the second AI task analysis are shown in Table 4.

Table 4. AI Task Analysis #2

Inputs	Prompt Key Elements	Outputs
<p>ISD- and client-approved task list</p>	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis, and the applicable part to use • The data to analyze • Specific tasks to include in the analysis • Type of analysis to perform, including specific parameters to look for • Specific questions to answer: Train / No Train • Level at which to break down each task: subtasks, steps, sub-steps • Desired output and format, including categorization of tasks and specific parameters to include • Confidence rating of the accuracy and relevance of the outputs 	<p>For each task:</p> <ul style="list-style-type: none"> • List of sub-tasks and steps for each sub-task, formatted as 1.1, 1.1.1; 1.2, 1.2.1; etc. <p>For each sub-task or step:</p> <ul style="list-style-type: none"> • Train/No Train decision • Knowledge, Skills, or Attitude (KSA) category • Hazard severity, difficulty, frequency, and criticality of each task • Conditions necessary to complete • Standards • Resources and tools needed • Any safety or other guidelines

The AI integrates all the analyzed data and synthesizes information into a coherent response. Before delivering the response, the AI checks for the information's quality, relevance, and accuracy. It provides a confidence level for the returned results, which can inform the stringency of the instructional designer's review.

ISD Actions

The instructional designer reviews this task list and working with the client and SMEs determines the final set of behaviors that need to be trained. This task list is then input to the Learning Analysis to determine learning objectives and specific strategies to both teach the required knowledge, skills, and attitudes, and evaluate the learning outcomes.

LEARNING ANALYSIS

The Learning Analysis takes the data generated from the Task Analysis to create specific learning objectives properly formatted with behaviors, conditions, and standards. Based on these learning objectives and taking into account the organizational context and the unique needs of the target audience, ADDIEMate's analysis tool generates recommendations for learning strategies organized into a structure for building the requisite knowledge, skills, and attitudes. For each learning objective, it also generates a relevant assessment strategy.

This is a two-step process, consisting of generation of:

- 1) Learning objectives and learning structure
- 2) Instructional and assessment strategies

AI Learning Analysis #1

The inputs, key prompt elements, and outputs for the first AI learning analysis are shown in Table 5.

Table 5. AI Learning Analysis #1

Inputs	Prompt Key Elements	Outputs
<ul style="list-style-type: none"> • The outputs of the organizational analysis • The outputs of the audience analysis • The outputs of the task analysis • The library of uploaded data – either all of it or selected items • Data from other related analyses • Publicly available data on the internet, if desired 	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis, and the specific part of the model to use • The data to analyze • Specific tasks to include in the analysis • Connection to other analyses, including organizational, target audience, and task analyses • Specific target audience for the analysis • Type of analysis to perform, including specific parameters to look for and specific categorizations • Level at which to identify learning objectives: terminal and enabling • Desired output and format, including categorization of objectives, specific parameters to include, and sequencing and hierarchy • Confidence rating of the accuracy and relevance of the outputs 	<ul style="list-style-type: none"> • Relevant terminal and enabling learning objectives needed to achieve the selected performance goal for the target audience • For each learning objective: <ul style="list-style-type: none"> ○ Conditions for demonstrating that behavior ○ Standards to which it must be performed ○ Categorization as Knowledge, Skill, or Attitude • Initial hierarchy for building performance, from foundational to higher-level skills

ISD Actions

The instructional designer, with other stakeholders and SMEs, as desired, reviews the learning objectives, selecting the most relevant ones and adding any that they think are missing. Once the learning objectives are solidified, the instructional designer can ask ADDIEMate to generate recommendations for learning strategies to achieve those objectives.

AI Learning Analysis #2

The inputs, key prompt elements, and outputs for the second AI learning analysis are shown in Table 6.

Table 6. AI Learning Analysis #2

Inputs	Prompt Key Elements	Outputs
ISD- and client-approved learning objectives	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis • The model to use for the analysis, and the specific part of the model to use • The data to analyze • Specific performance goal and learning objectives to include • Connection to other analyses, including organizational, target audience, and task analyses • Specific target audience for the analysis • Type of analysis to perform, including specific parameters to look for, specific categorizations, and both instructional and assessment strategies • Criteria for selecting solution options • Categorization of solution options • Desired output and format • Confidence rating of the accuracy and relevance of the outputs 	<ul style="list-style-type: none"> • Three options for a recommended learning solution to achieve the selected learning objectives for the target audience to achieve the designated performance goal • Applicable assessment strategies

ISD Actions

The instructional designer can review the learning solution options with the client to determine the one that will best suit their needs. They can then submit this information to a formatted Word document, which can be saved, edited, and submitted as a formal deliverable.

At this phase of the analysis, the instructional designer may already have formed their own ideas of what the solution should be. ADDIEMate provides the rigor to ensure that the ultimate solution goes beyond this “gut-instinct” solution to one that is based on solid rationale, aligned with the organizational goals and priorities, and tailored to the unique needs of the target audience. In addition, it ensures that designers and developers stay true to the analysis findings as they build out the solution.

MEDIA ANALYSIS

The Media Analysis finetunes the learning solution(s) identified in the Learning Analysis by identifying the most effective media to use to implement that solution. To determine optimal use of media, ADDIEMate analyzes such factors as the type of task (individual or collective), the type of objective (Knowledge, Skill, Attitude) and its placement on Bloom’s taxonomy, sensory requirements of the task, the learning strategy identified, the assessment strategy identified, the characteristics of available media, and any constraints in the organizational environment.

AI Media Analysis

The inputs, key prompt elements, and outputs for the AI media analysis are shown in Table 7.

Table 7. AI Media Analysis

Inputs	Prompt Key Elements	Outputs
<ul style="list-style-type: none"> • The outputs of the organizational analysis 	<ul style="list-style-type: none"> • Context for the analysis: the role the AI is playing, the purpose of the analysis 	<ul style="list-style-type: none"> • Updated recommended learning solution to

Inputs	Prompt Key Elements	Outputs
<ul style="list-style-type: none"> • The outputs of the audience analysis • The outputs of the task analysis <ul style="list-style-type: none"> • The outputs of the learning analysis, including selection of the specific solution option(s) to address • The library of uploaded data – either all of it or selected items • Data from other related analyses • Publicly available data on the internet, if desired 	<ul style="list-style-type: none"> • The model to use for the analysis, and the specific part of the model to use • The data to analyze • Specific tasks and learning objectives to include • Connection to other analyses, including organizational, target audience, and task analyses • Specific target audience for the analysis • Type of analysis to perform, including specific parameters to look for and specific categorizations • Criteria for selecting media • Desired output and format • Confidence rating of the accuracy and relevance of the outputs 	<p>include specific media recommendations with rationale and time estimates</p> <ul style="list-style-type: none"> • Analysis Report that details analysis activities, findings, and recommendations • Design Plan that provides more details about the recommended learning solutions and how they can be implemented

ISD Actions

The instructional designer reviews the updated solution with the client stakeholders and SMEs and further refines it as desired. Once the final solution has been identified, the details can be exported to Word, Excel, or PowerPoint files for sharing with others as inputs to the design process.

TRANSITION TO DESIGN

Through ADDIEMate, the outputs of the analysis, including the Analysis Report, provide a seamless transition into design and development. As ADDIEMate’s Design, Development, Implementation, and Evaluation functionality is built out, instructional designers will have a one-stop shop for learning solution design and development, one that integrates each phase of the ADDIE model so that developers remain faithful to the vision and rationale established through the analysis.

As designers and developers are added to the project, the project owner can further segment the information to provide members of the design and development team with the specific information they need to do their jobs, such as specific media requirements and constraints, or the specific learning objectives for specific segments of the solution. In this way, designers and developers can focus on a specific module or lesson while remaining aware of the larger course context.

Everyone assigned to a project through ADDIEMate can share, comment, and chat through the tool as a means to collaborate with the project team. ADDIEMate keeps all users updated with notifications in the tool, as well as dashboards for project status and other pertinent details or metrics.

DATA SECURITY

The ideal for data security is to use a privatized AI solution in which analyses are contained internally and not shared externally (Accenture, 2023). ADDIEMate is currently hosted within a paid Team GPT that allows the information uploaded into it to remain private to the organization and not be used for training external AI applications. In addition, ADDIEMate incorporates typical cybersecurity best practices, such as:

- Minimizing use of data widely available on the Internet in favor of using data that instructional designers have collected and vetted
- Making it clear to clients what data is used to train the model and allowing instructional designers to select the specific data they want to use
- Incorporating ISD checks to validate the outputs of the AI analysis and identify biased or inaccurate data
- Using a separate AI model to monitor and score ADDIEMate’s outputs

- Using known and vetted AI tools

As development of ADDIEMate evolves, additional security measures will be implemented based on current best practices (Chen et al, 2019) (Oseni et al, 2020).

CONCLUSION

In addition to leveraging the powerful data analysis functionality of AI, ADDIEMate provides automation of common analysis activities with guidance through a proven analysis process. It provides flexibility in terms of where the analysis begins and ends, as well as what data is included. It helps instructional designers to quickly prepare the deliverables that clients are looking for, including the Analysis Report and design inputs. It then ensures that the Analysis outcomes continue to be considered during design and development. By providing a single repository for the company's learning projects, ADDIEMate allows designers to leverage the work that others have done to expedite their analyses. Each analysis project further trains the AI and refines the accuracy of ADDIEMate's analyses.

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