GenMentor

LLM-powered Multi-agent Framework for **Goal-oriented Learning** in Intelligent Tutoring System

https://tianfuwang.tech/gen-mentor/

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Background

Intelligent Tutoring System (ITS)

ITSs have revolutionized education by personalizing learning experiences.

Traditional ML-based ITS

Rule-based and ML models
Static, predesigned curricula

MOOC (Massive Open Online Course)

Learner modeling
Personalized feedback
Learning Path scheduling

Limitations

Fragmentation Across Modules
Static Content Delivery
Lacks flexibility for emerging topics

LLM-based Dialogue ITSs

Large Language Models Chatbot
Dynamic content generation

Microsoft Copilot

Dialogue-based interaction
Natural and engaging
Real-time Q&A

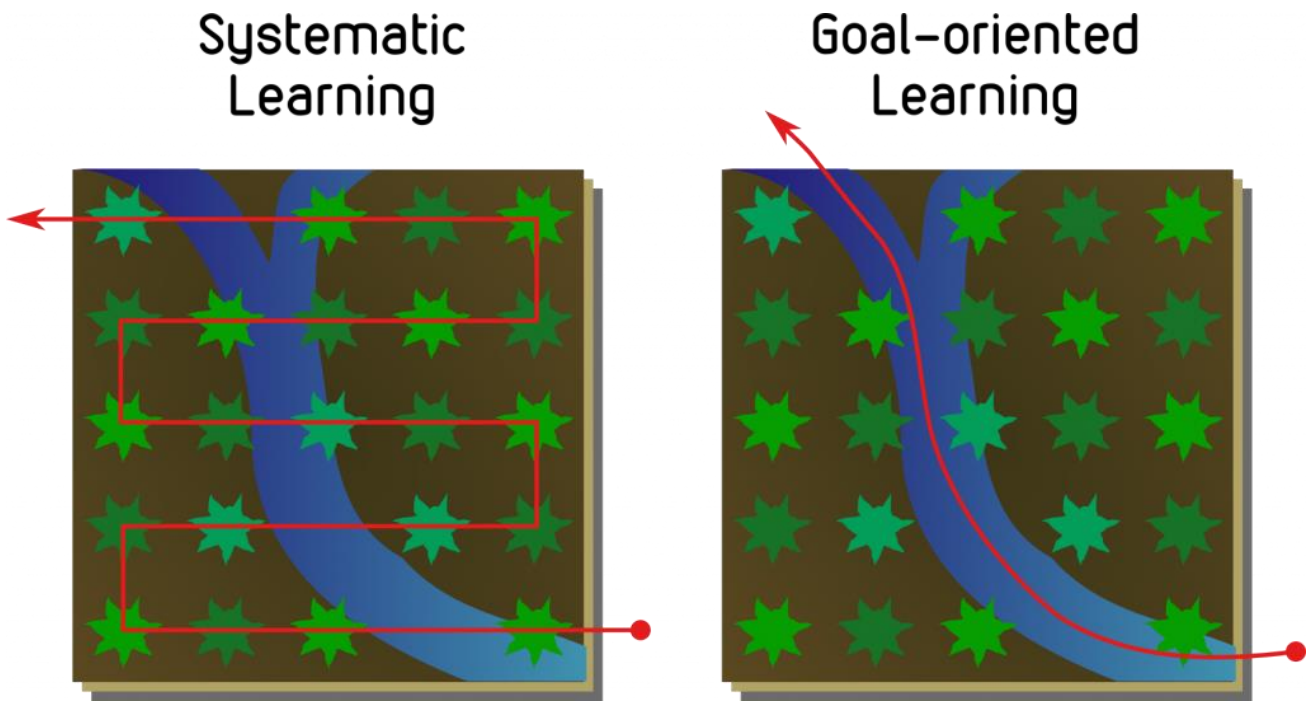
Limitations

Reactive Nature for Q&A
Limited Learner Understanding
Limited Quality and User Experience

Background

Goal-oriented Learning in Professional Education

A personalized learning paradigm that focuses on achieving specific objectives efficiently



https://nathanwyand.com/2019/02/27/systematic-vs-goal-oriented-learning/

Background

Goal-oriented Learning

A personalized learning paradigm that focuses on achieving specific objectives efficiently

Support personal and career-specific goals in professional and lifelong learning contexts.

Seek a new job

acquire job-related skills

Complete an assigned task

master task-related skills

Weakened Motivation

Uncertainty about where to start or which skills to prioritize reduce engagement and focus.

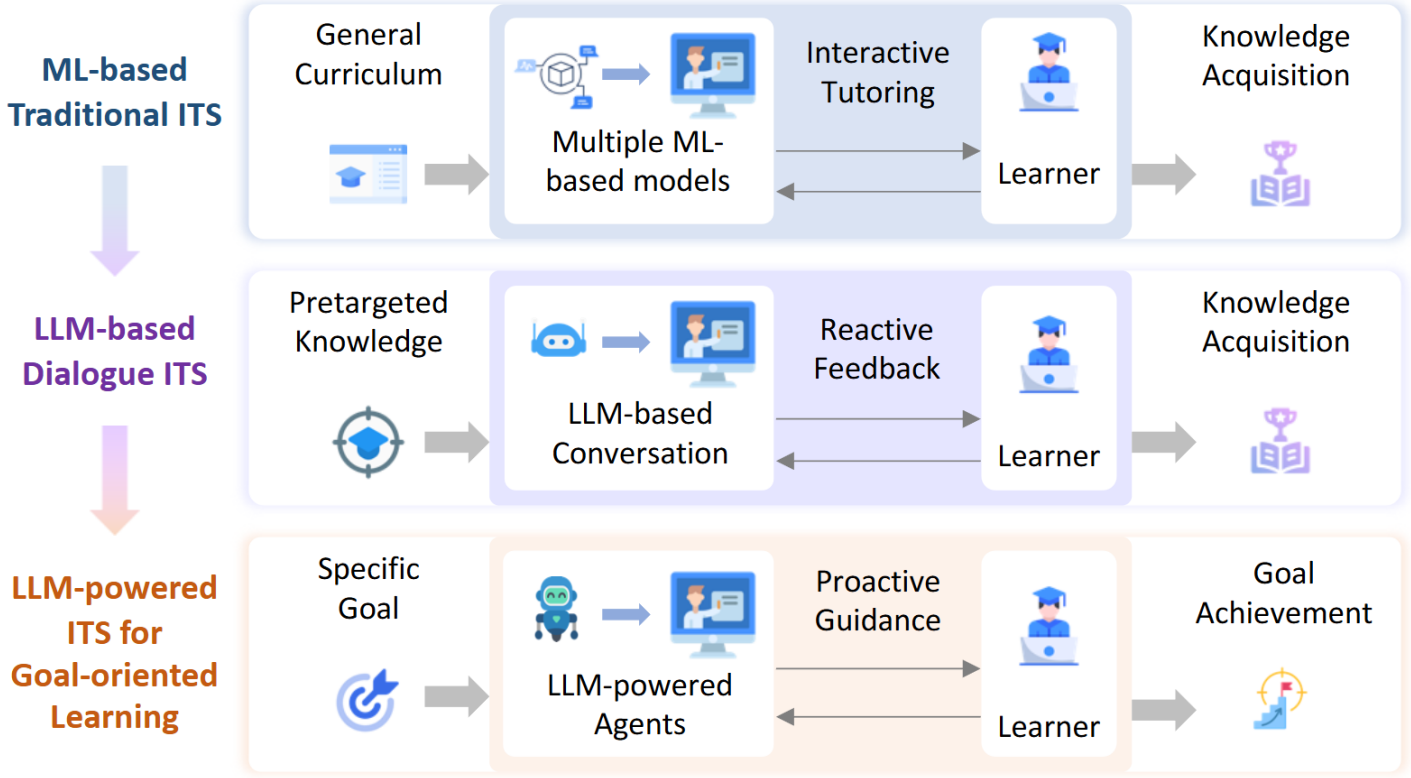
Inefficient Process

Lack of clear guidance leads to wasted effort on irrelevant content and delayed progress.

Background

Paradigm Comparison

Goal-oriented ITSs aim to proactively guide learners to achieve their specific goals.



Understand complex intentions	**LLM**	Generate versatile content

Challenges

Skill Gap Identification

Accurately mapping learner goals to required skills.

Adaptive Learner Modeling

Continuous profiling of comprehensive learner status.

Personalized Resource Delivery

Adapts pathways and resource to evolving learner needs.

Definition

Goal-oriented ITS

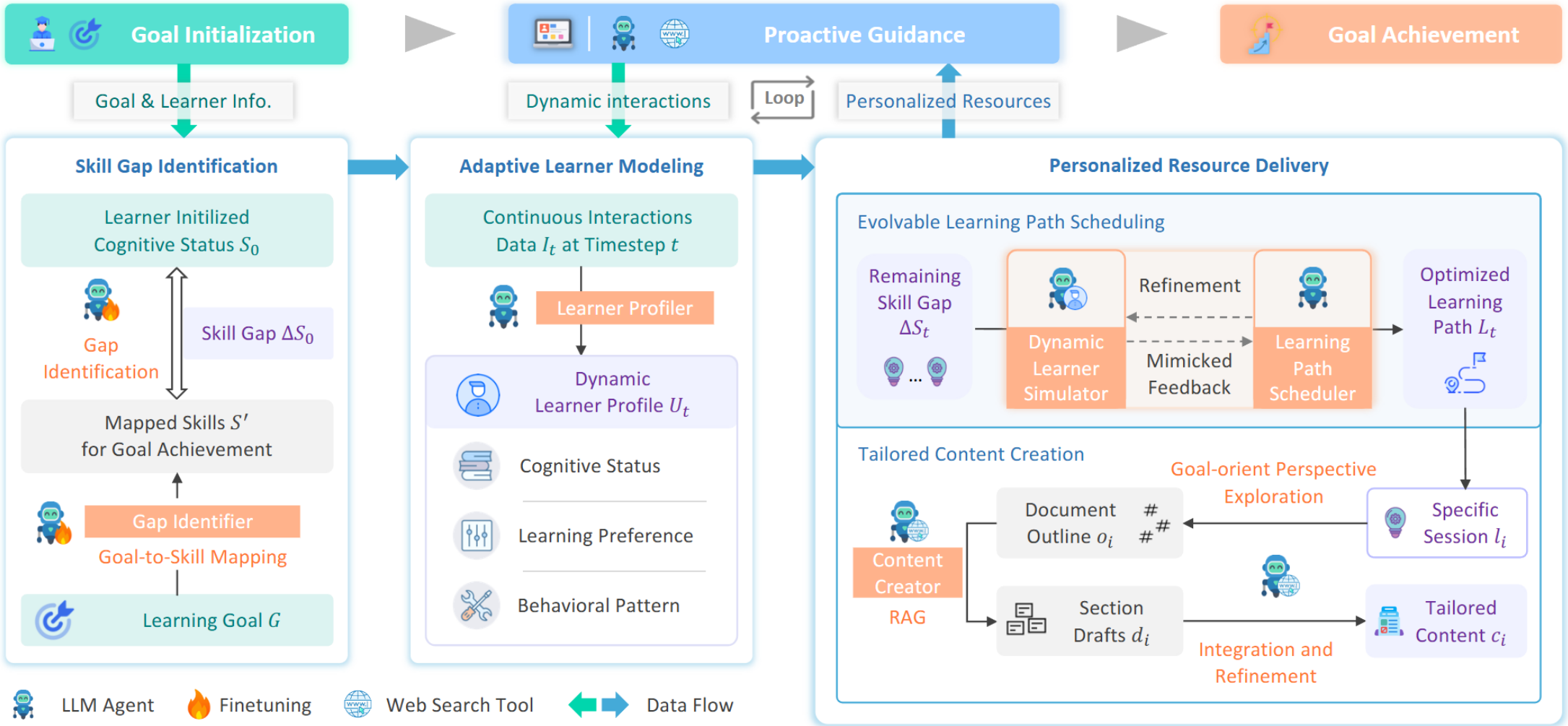
Customize learning recourse, and quickly acquire the knowledge needed for goal

Skill Gap Identification	Identifies the skills gap between the learner's current knowledge and the skills required to achieve their goals	Necessity Completeness
Adaptive Learner Modeling	Continuously update learner profiles by incorporating interaction data to track dynamic learner's status	Comprehensiveness Adaptation
Personalized Resource Delivery	Dynamically schedules an engaging learning path and delivers tailored learning content	Personalized Goal-targeted

Framework

Overview of GenMentor

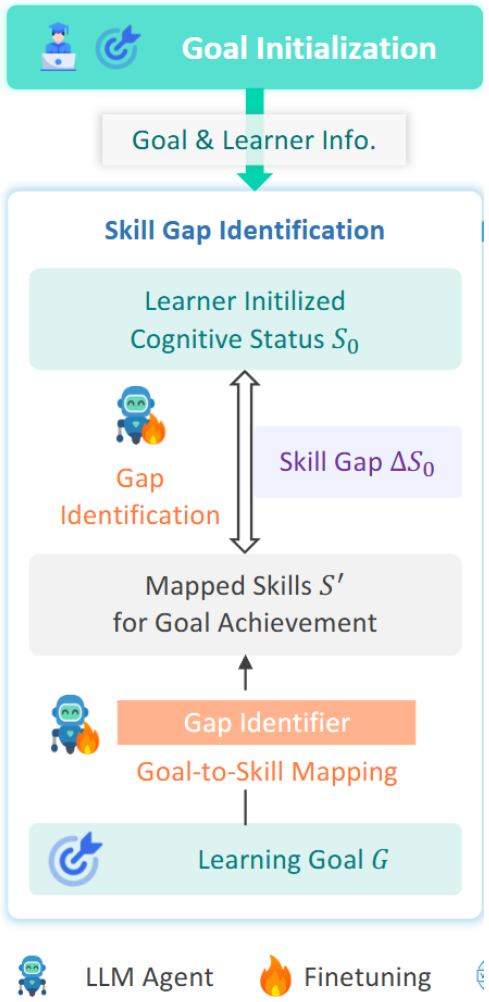
LLM-powered Multi-agent Framework for Goal-oriented Learning in ITS



Framework

Skill Gap Identification

Mapp a learning goal to the required skills and identifying the skill gaps



Challenges in Skill Gap Identification

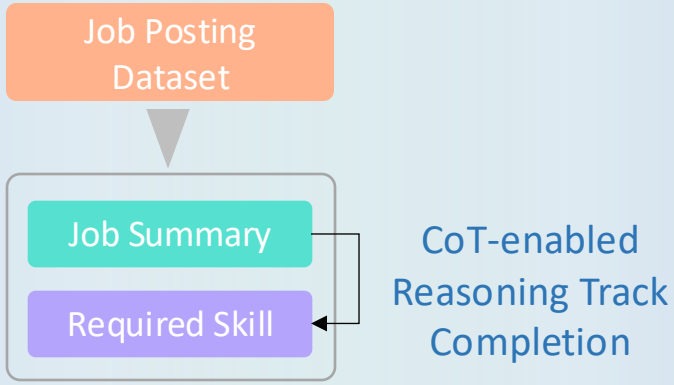
Ambiguity in Goals

Goals are often high-level or abstract, making them hard to map directly to skills

Unnecessary or incomplete Skills

Direct prompt engineering might include redundant or incomplete skills

Goal-to-Skill Dataset Construction



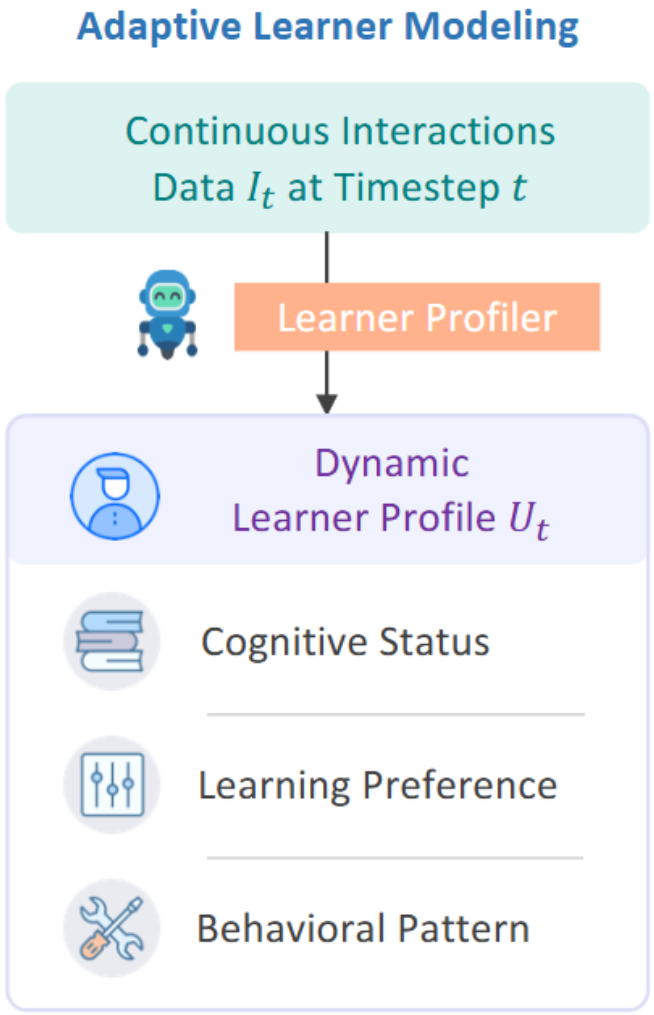
Gap Identification Process

- Maps the learning goal to required skills
- Assess learner's current skills and level
- Identify the skill gap for goal achievement

Framework

Adaptive Learner Modeling

Comprehensive and dynamic learner profile, updated continuously with newly interactions



Illustrative Example

A learner aiming to become a Data Scientist:

- Cognitive Status: Tracks progress in Python, SQL, and machine learning.
- Learning Preferences: Adjusts between concise tutorials or detailed theory.
- Behavioral Patterns: Sends motivational prompts when engagement drops.

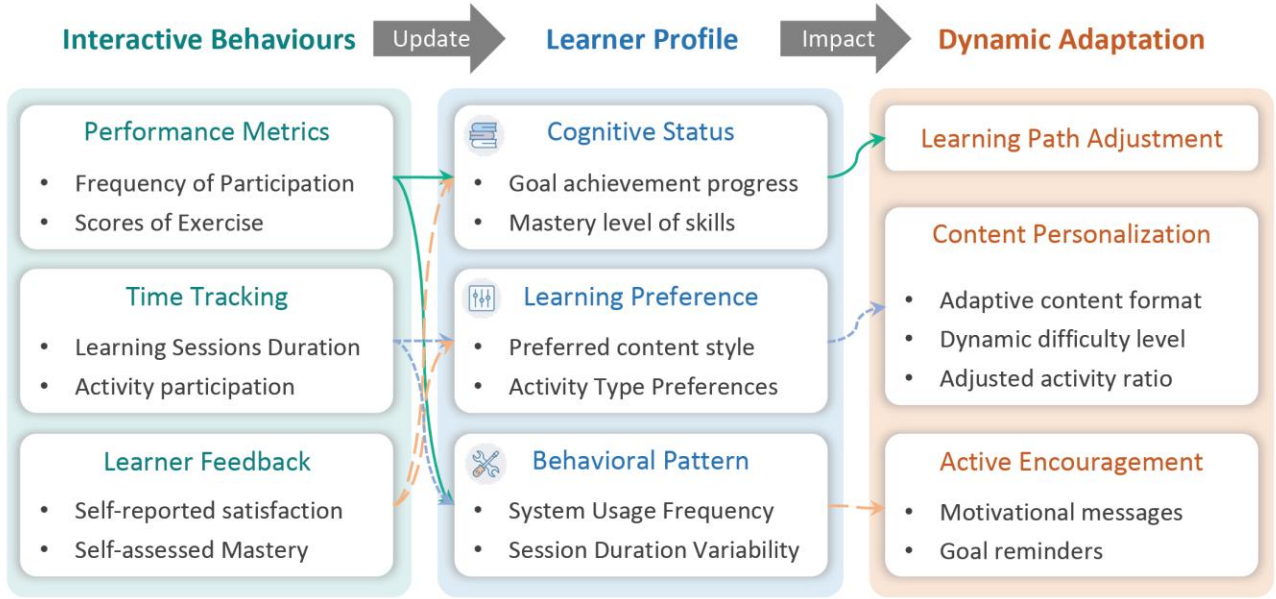
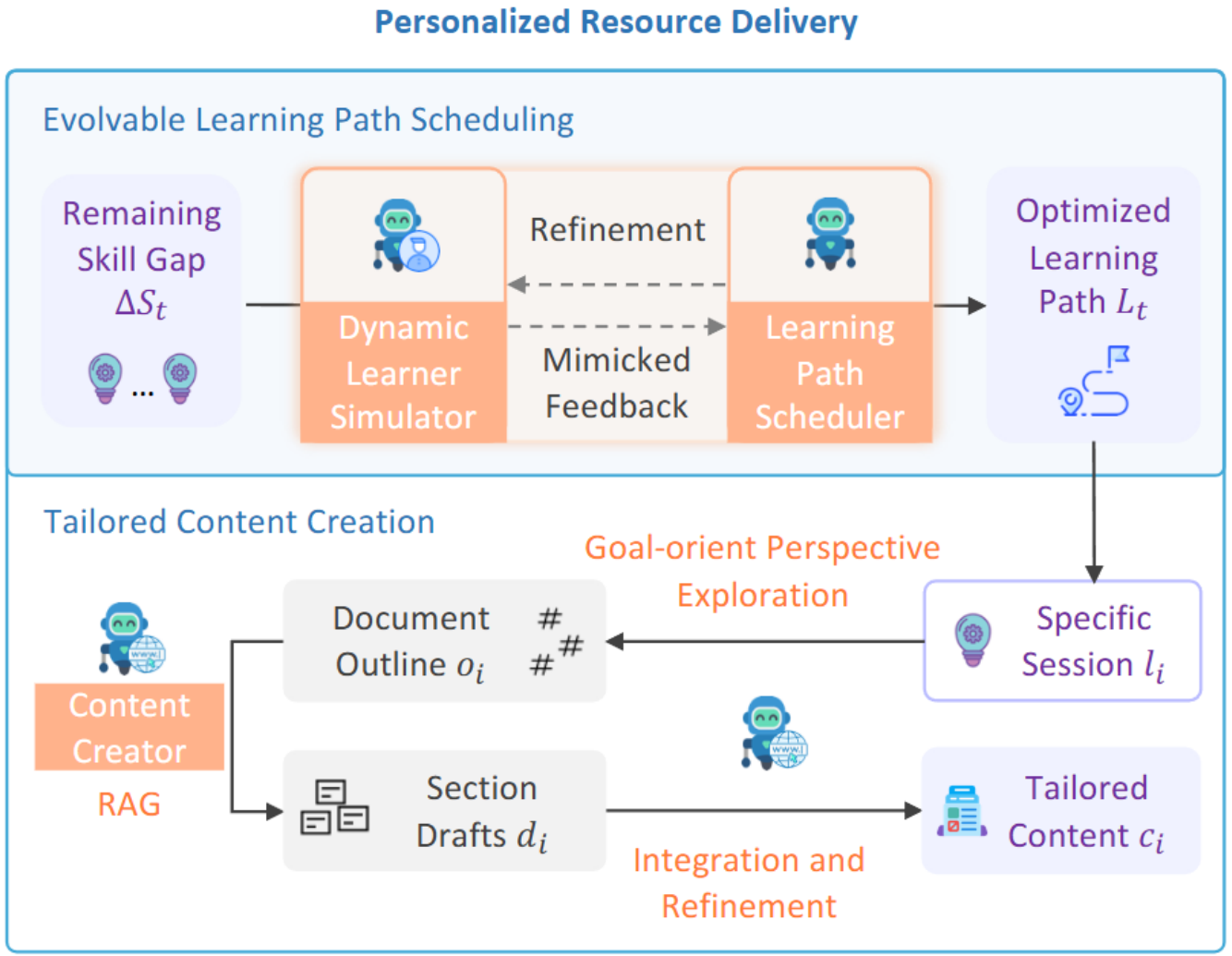


Figure 3: An illustration of dynamic learner modeling.

Framework

Personalized Resource Delivery

Tailor learning materials and pathways to a learner's unique profile, goals, and progress



Learner Simulator

Mimics learner feedback to refine

- Resource quality
  - (e.g., difficulty, relevance).
- Engagement
  - (e.g., interaction types).

Goal Relevance

Content Quality

Personalization

Engagement

Framework

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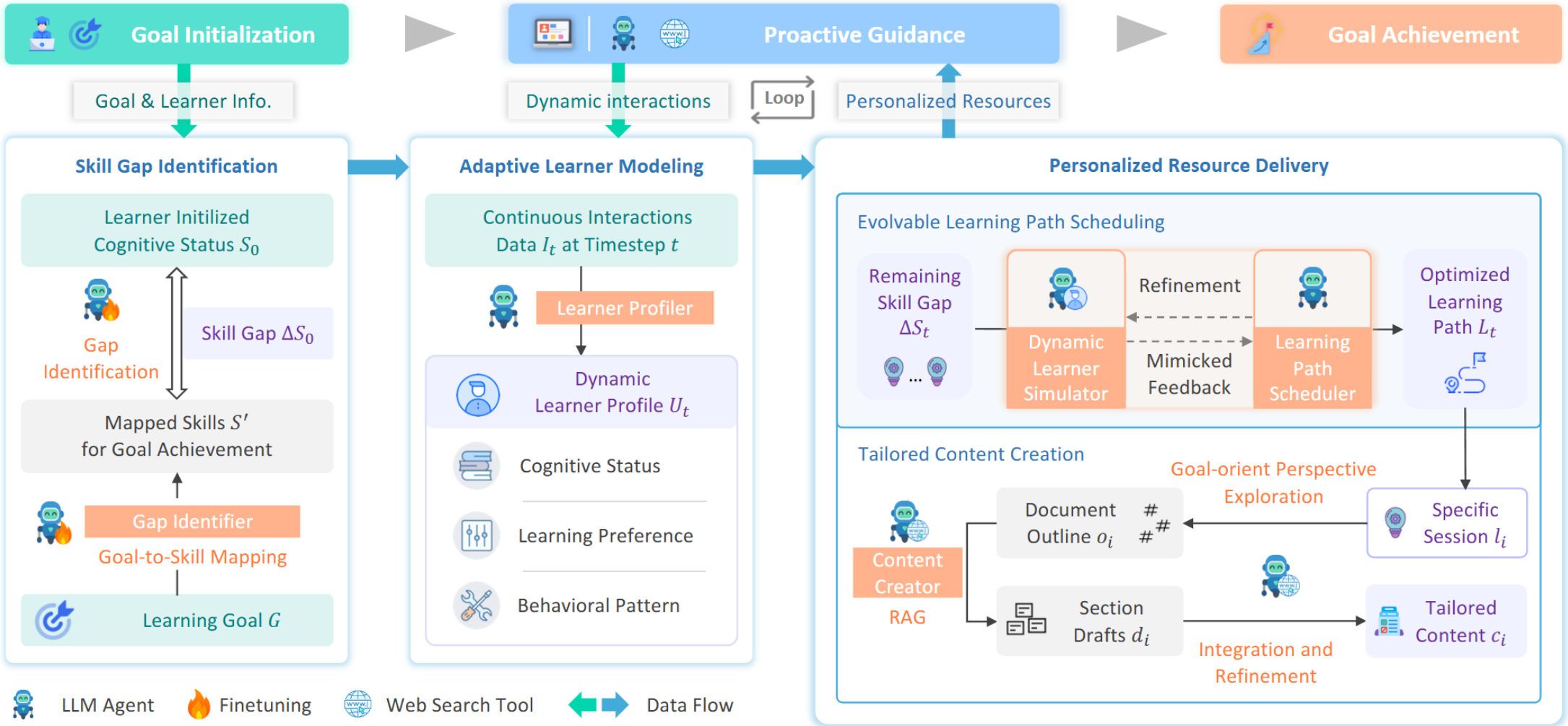


Experiment

Implementation & Experiments

Leverage LLMs to evaluate the system’ s performance on key ouputs

Implementation

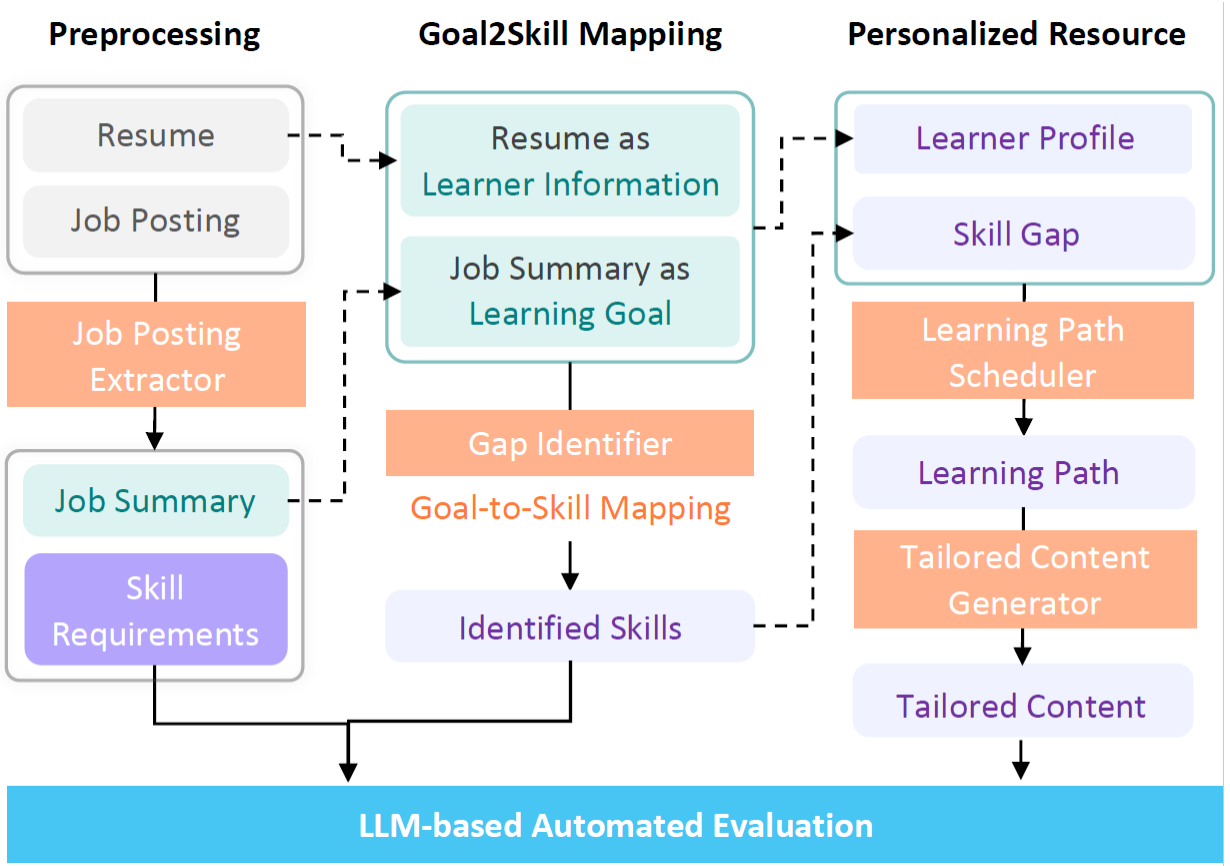
LLMs Used:
- GPT-4o (2024-08-06)
- LLaMA 3.2 (3B)

Web Tool:
Bing Search

Fine-Tuning:
Azure AI Studio

RAG Embedding:
Text-embedding-3-small

LLM-based Automated Evaluation



Experiment

LLM-based Automated Evaluation

Support personal and career-specific goals in professional and lifelong learning contexts.

A. Evaluating Goal-to-skill Mapping

Table 1: Evaluation results on goal-to-skill mapping.

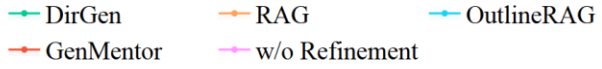
		Recall	Precision	Goal Alignment
GPT4o	DirPrompt	0.42	0.31	3.45
	CoTPrompt	0.48	0.39	3.51
	GenMentor	**0.67**	0.63	**4.28**
	w/o Tracks	0.63	**0.67**	4.05
Llama	DirPrompt	0.37	0.35	3.18
	CoTPrompt	0.45	0.38	3.24
	GenMentor	**0.63**	**0.61**	**4.14**
	w/o Tracks	0.61	0.58	4.01

B. Evaluating Learning Path

Table 2: Evaluation results on Learning Path.

		Progression	Engagement
GPT4o	DirPrompt	3.95	3.80
	CoTPrompt	4.38	4.63
	GenMentor	**4.56**	**4.71**
Llama	DirPrompt	3.94	3.71
	CoTPrompt	4.07	4.17
	GenMentor	**4.09**	**4.32**

C. Evaluating Learning Content



(a) GPT4o

(b) Llama

Experiment

Human Validation and Evaluation

Support personal and career-specific goals in professional and lifelong learning contexts.

A. Human Validation on Automated Evaluation

The results show 5 out of 7 metrics exhibit a statistically significant positive correlation.

Table 3: Pearson correlation between two types of scores.

Category	Metric	Correlation	p-value
Goal2Skill Mapping	Goal Alignment	0.51	$< 4^{-2}$
Learning Path	Progression	0.47	$< 2^{-2}$
	Engagement	0.39	$< 3^{-1}$
Learning Content	Content Quality	0.52	$< 1^{-2}$
	Goal Relevance	0.46	$< 1^{-2}$
	Engagement	0.38	$< 4^{-2}$
	Personalization	0.42	$< 8^{-2}$

B. Human Preference Evaluation

GenMentor was more favored, showcasing its ability to produce high-quality outputs.

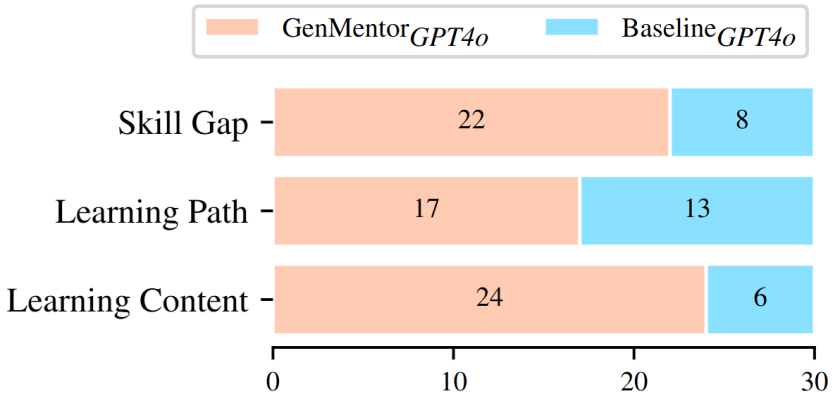


Figure 5: Human comparative preference.

Experiment

End-to-end Human Study

Support personal and career-specific goals in professional and lifelong learning contexts.

Practical Deployment in Microsoft

AIEP platform: empower employees with AI to enhance productivity
web-based application: tailored for goal-oriented learning.

20 employees from diverse professional fields

10 tech professionals (e.g., engineers, researchers).
10 non-tech professionals (e.g., product managers, HR).

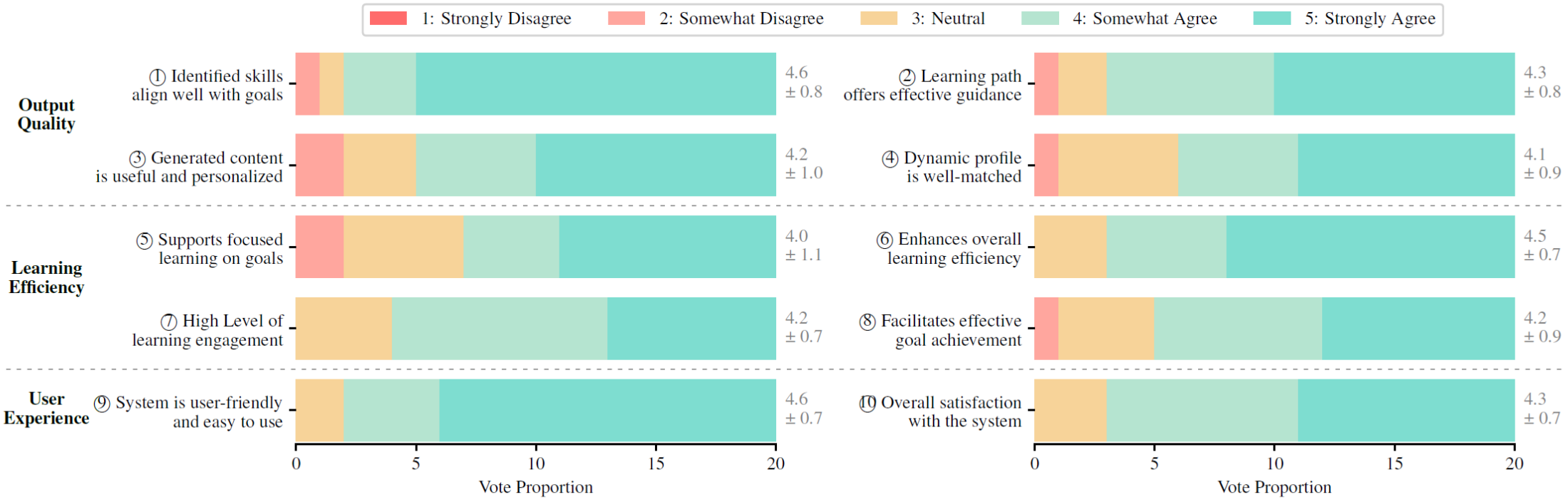
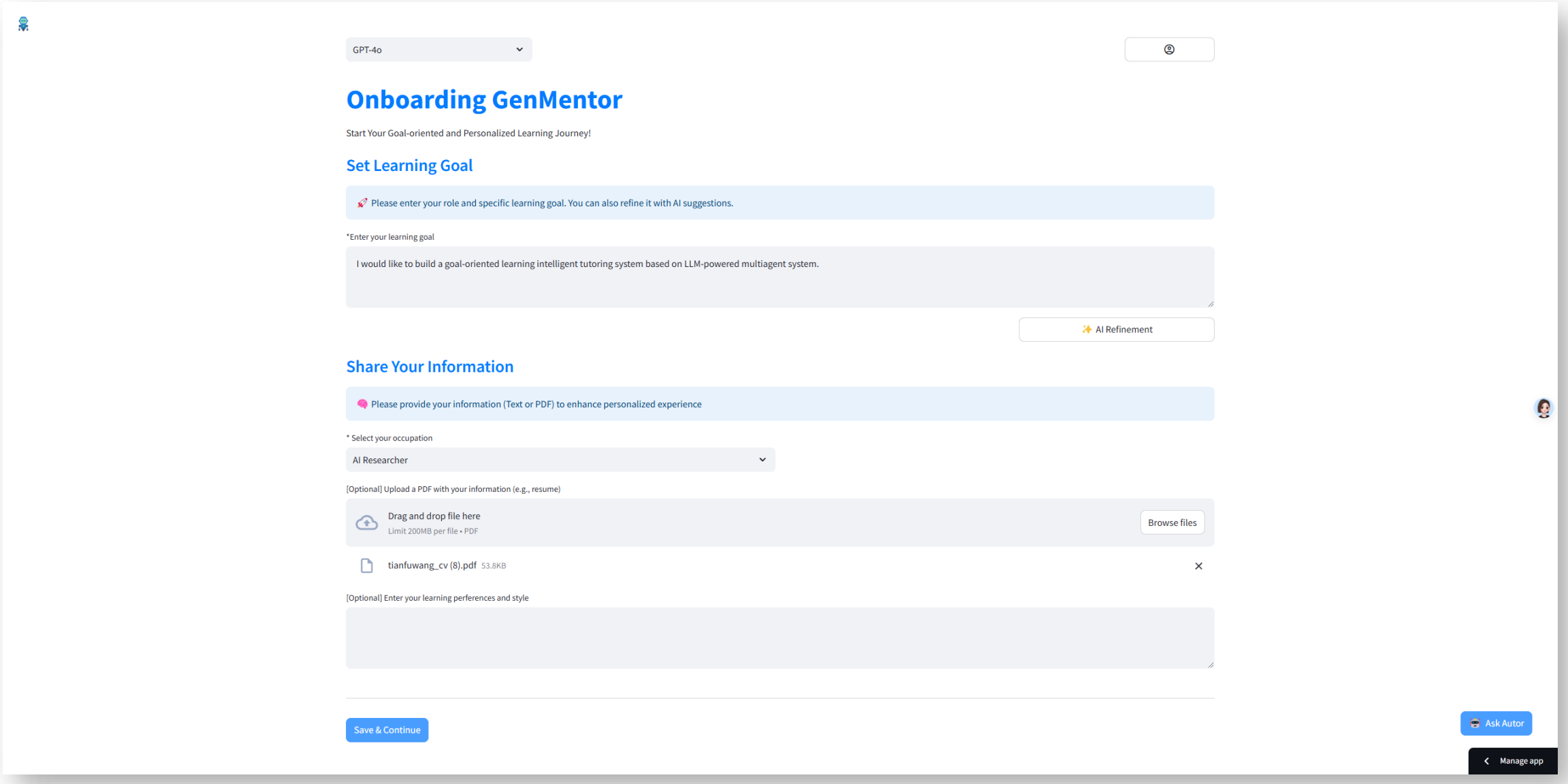


Figure 6: Questionnaire results from 20 participants (questions shortened for clarity). Gray texts are means and std. deviations.

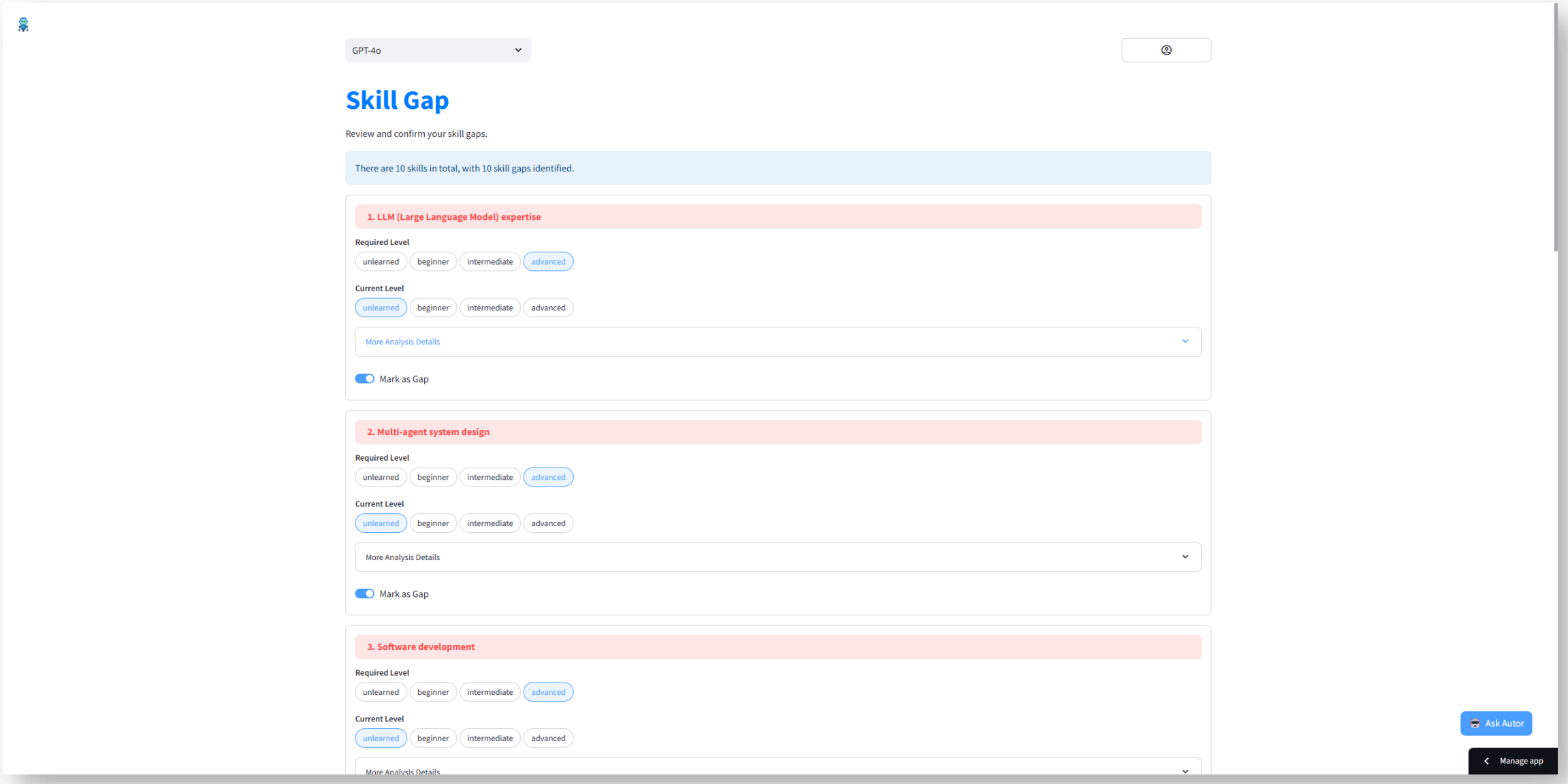
Web System

Goal Initialization



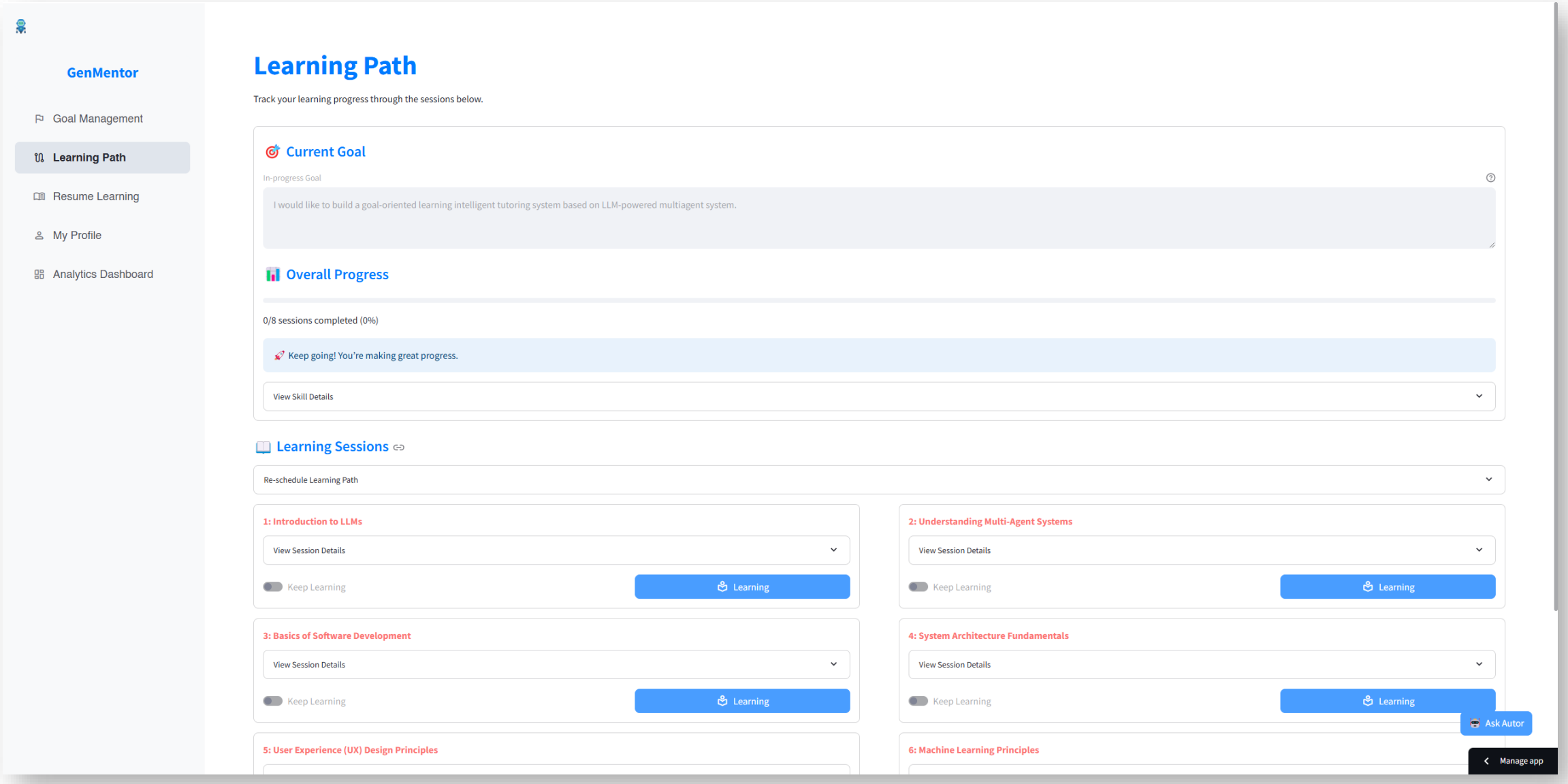
Web System

Skill Gap Identification



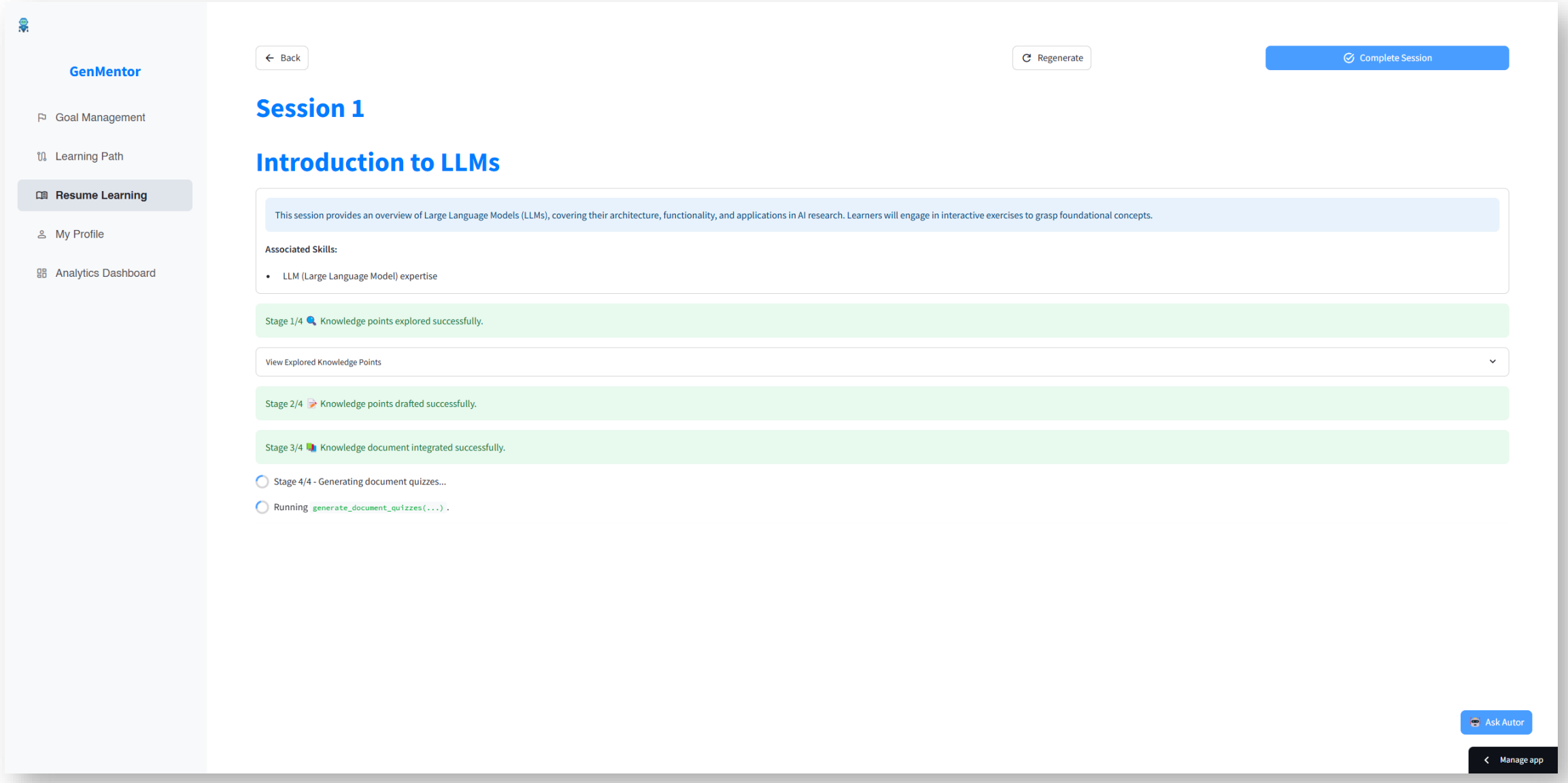
Web System

Learning Path Scheduling



Web System

Learning Content Creation



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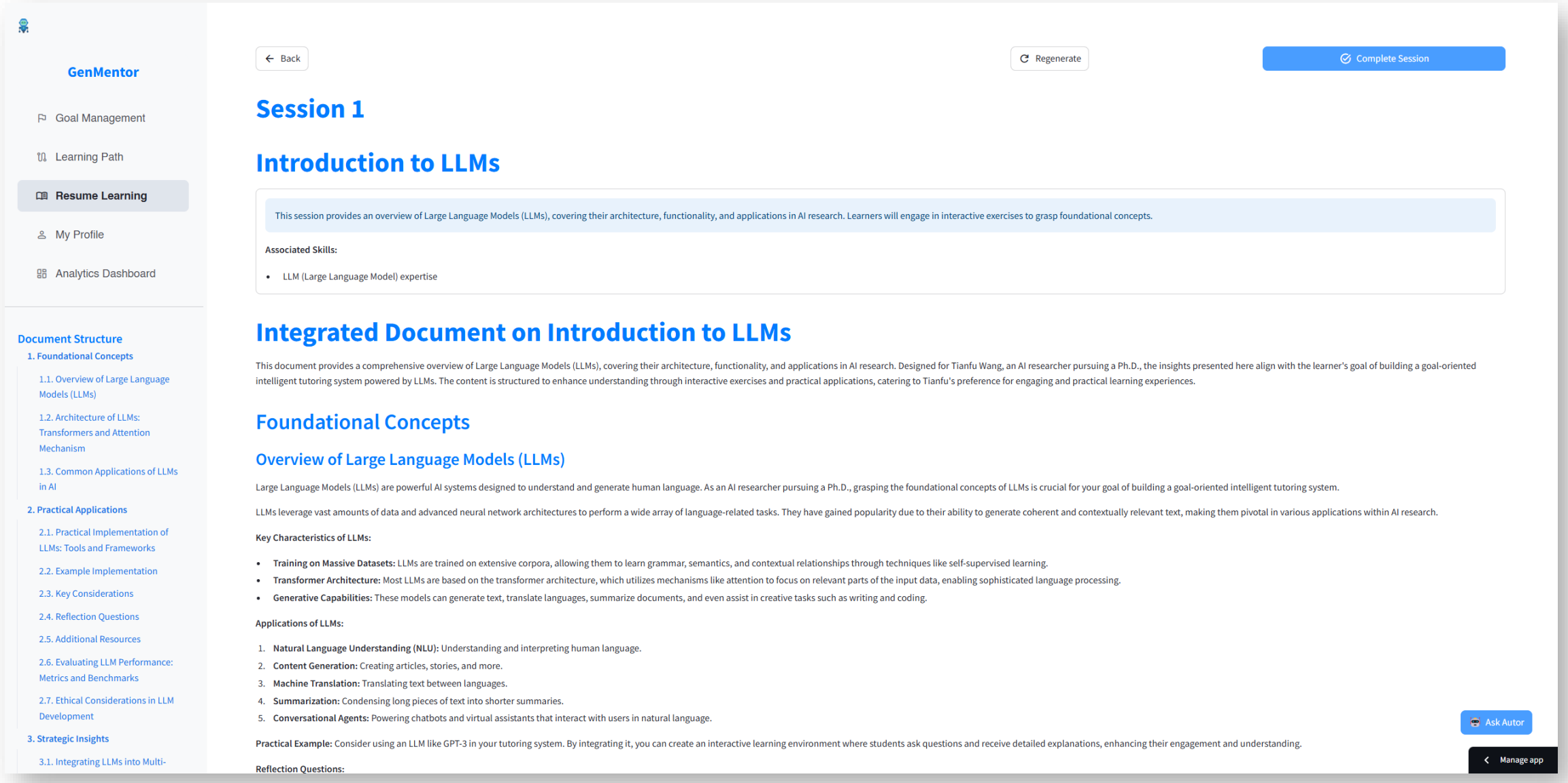

Web System

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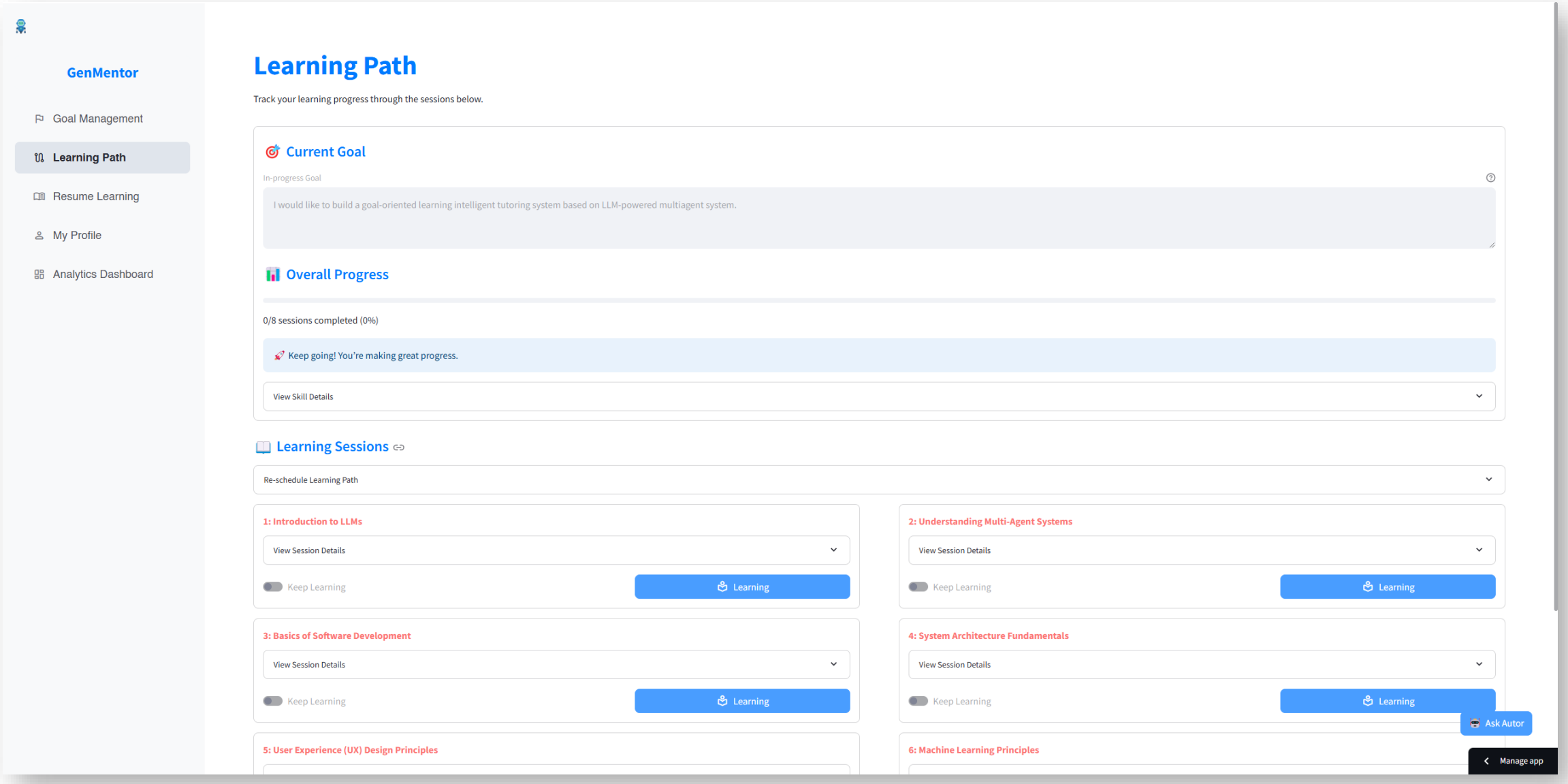
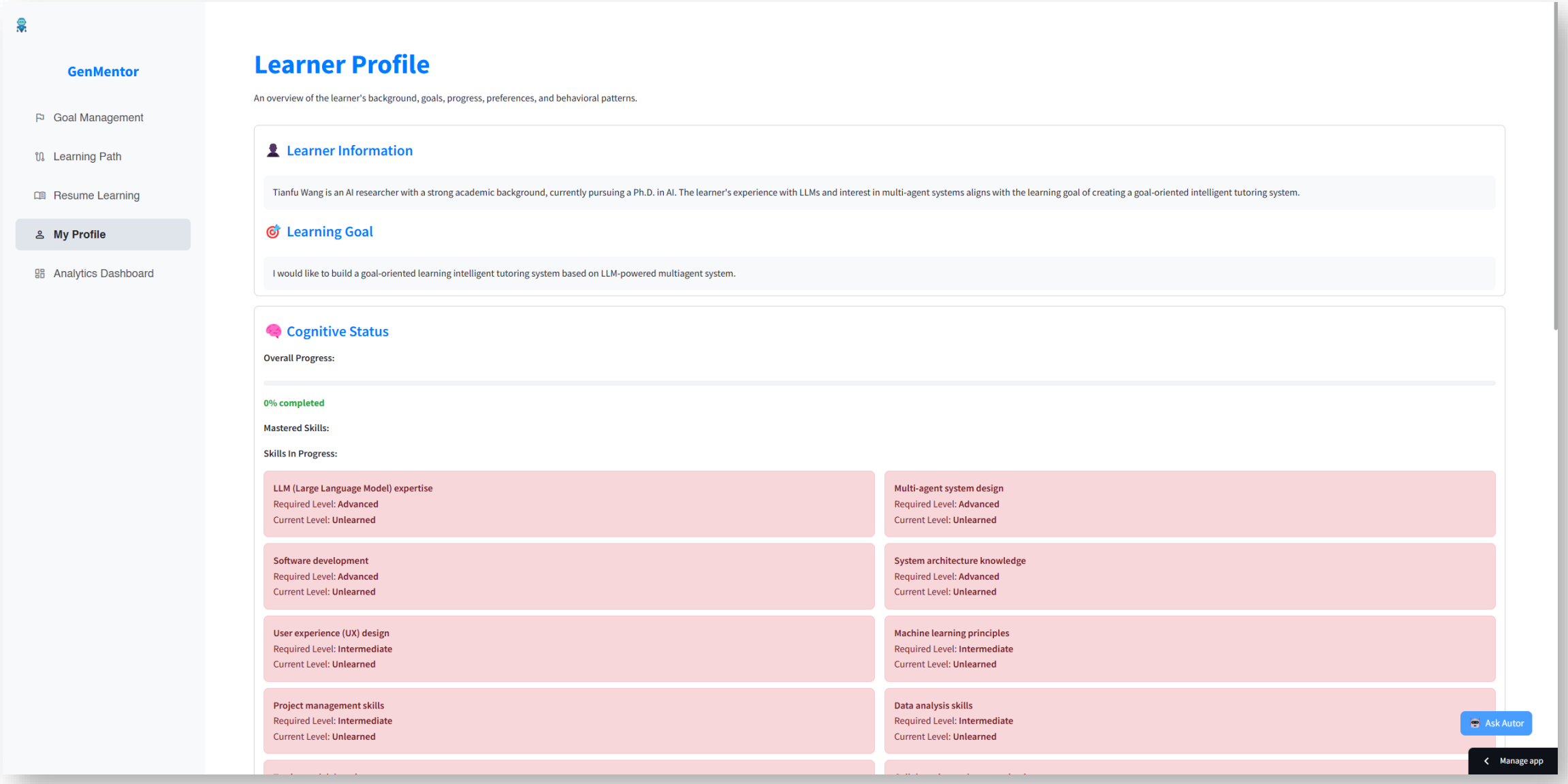
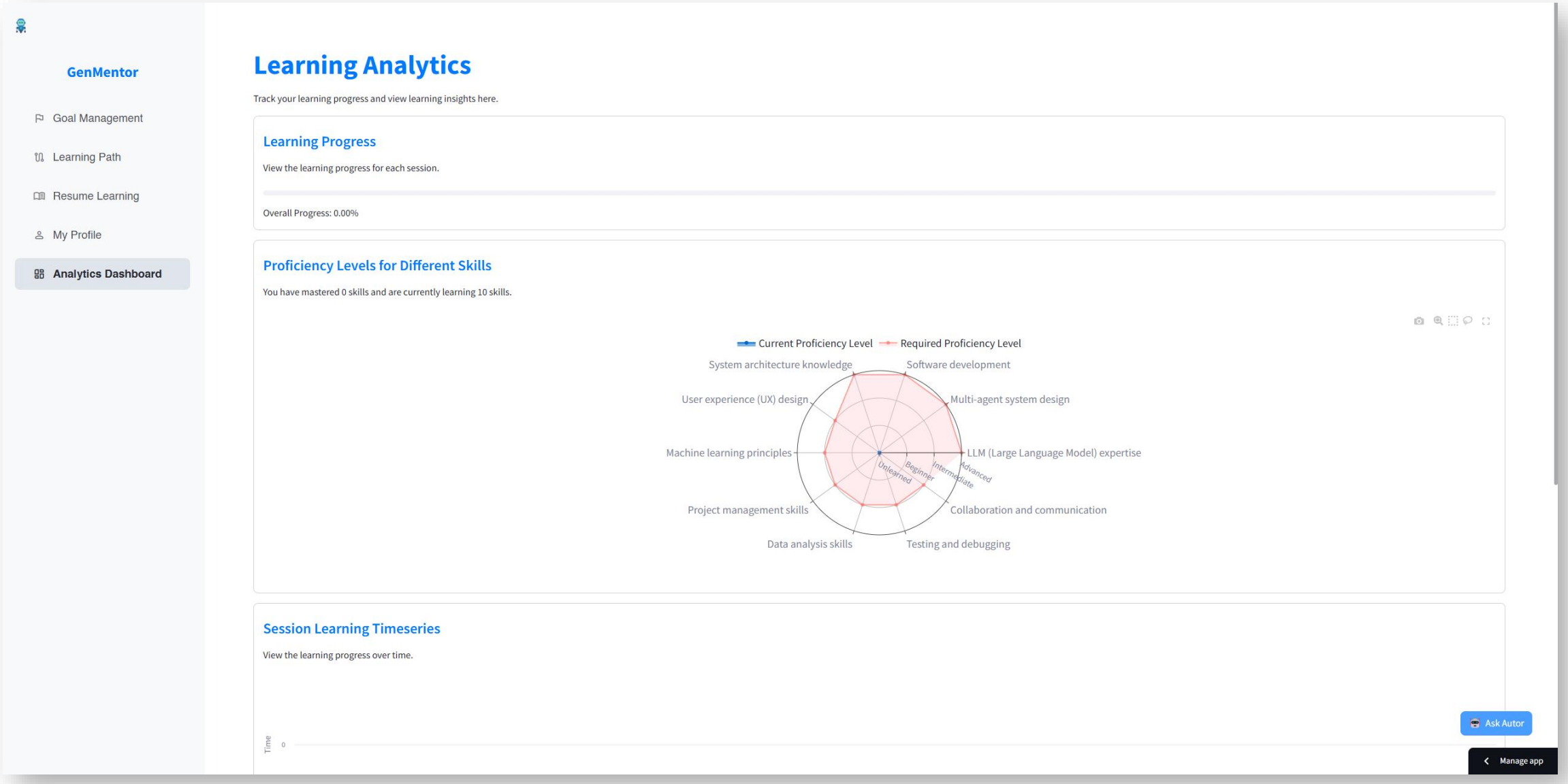


Web System

Learner Profile



Web System Analytics Dashboard



GenMentor

LLM-powered & Goal-oriented Tutoring System

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WWW 2025 (Industry Track) Oral

Thanks!

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