

GenMentor



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

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

Tianfu Wang, Yi Zhan, Jianxun Lian, Zhengyu Hu,
Nicholas Jing Yuan, Qi Zhang, Xing Xie, Hui Xiong



HKUST-GZ



Microsoft

ITSs have revolutionized education by personalizing learning experiences.



Traditional ML-based ITS

Rule-based and ML models
Static, predesigned curricula



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



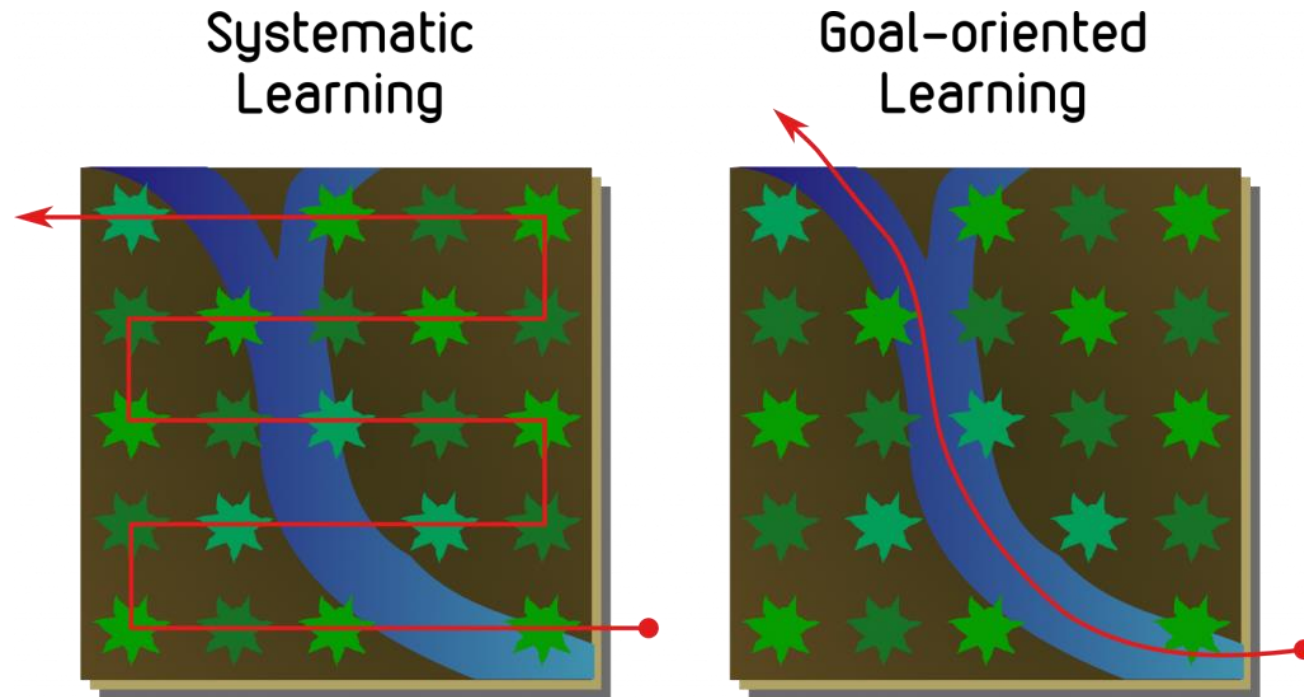
Microsoft
Copilot

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

Limitations

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

A personalized learning paradigm that focuses on achieving specific objectives efficiently

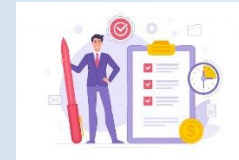


A personalized learning paradigm that focuses on achieving specific objectives efficiently

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



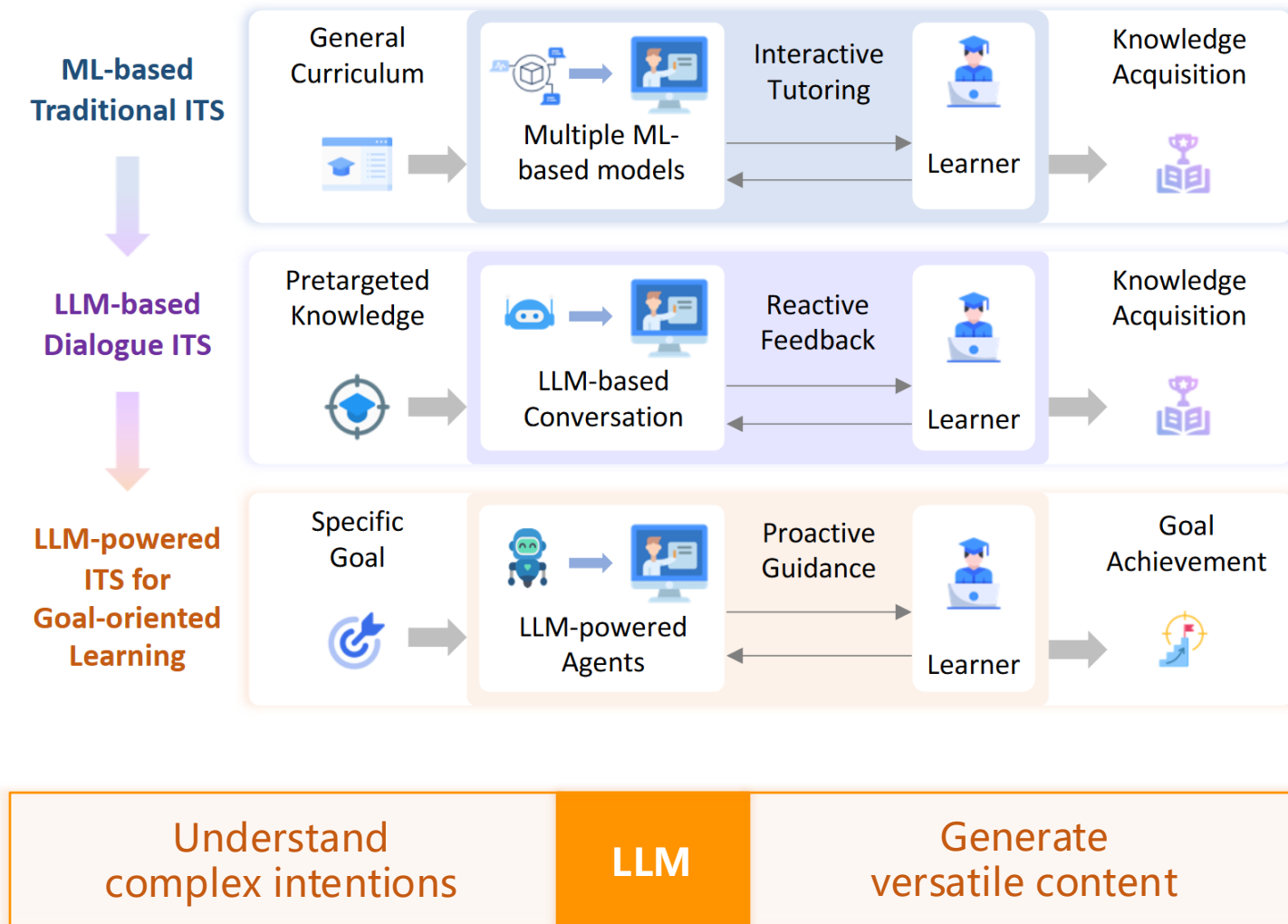
Weakened Motivation

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.

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



Challenges

Skill Gap Identification

Accurately mapping learner goals to required skills.

Adaptive Learner Modeling

Continuous profiling of comprehensive learner status.

Personalized Resource Delivery

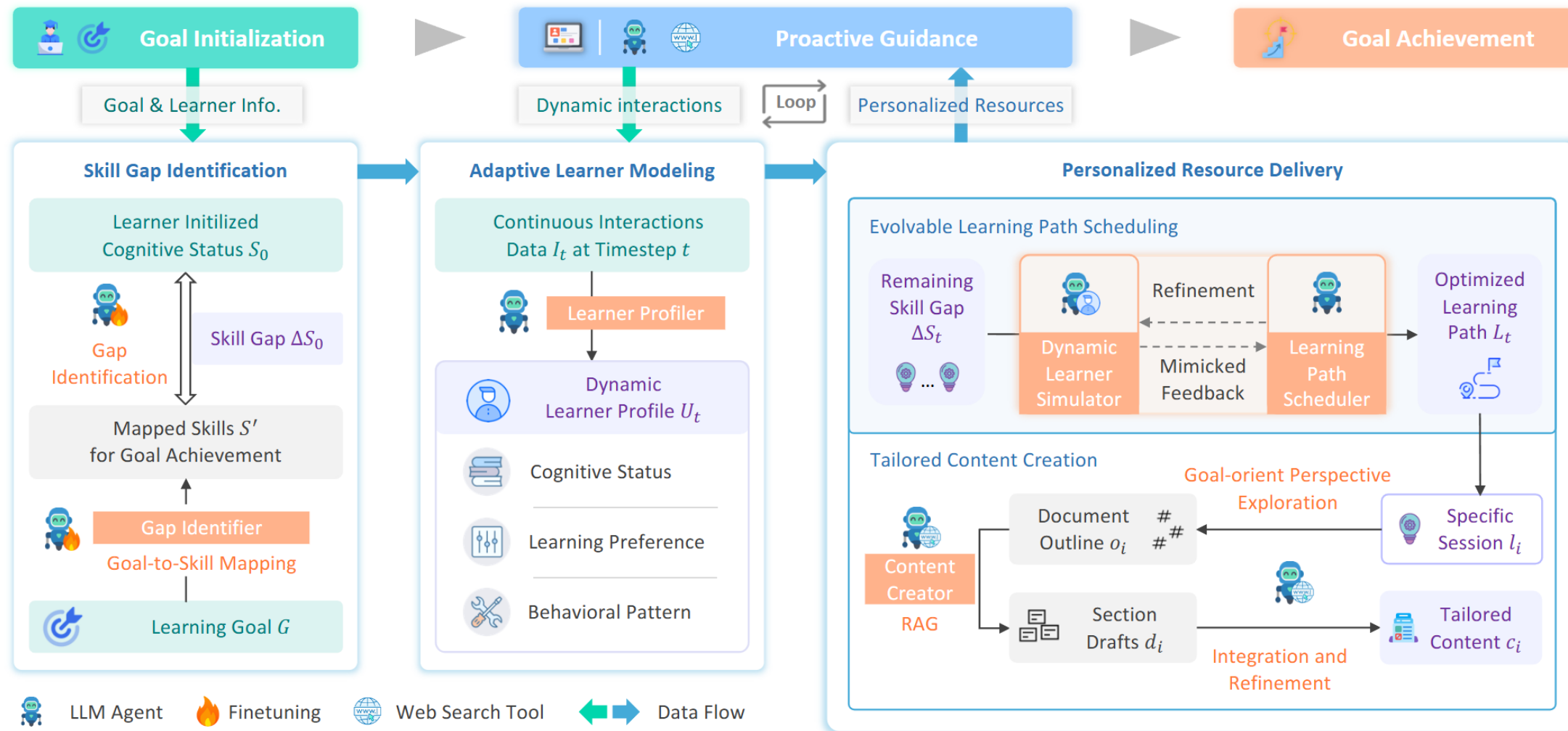
Adapts pathways and resource to evolving learner needs.

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

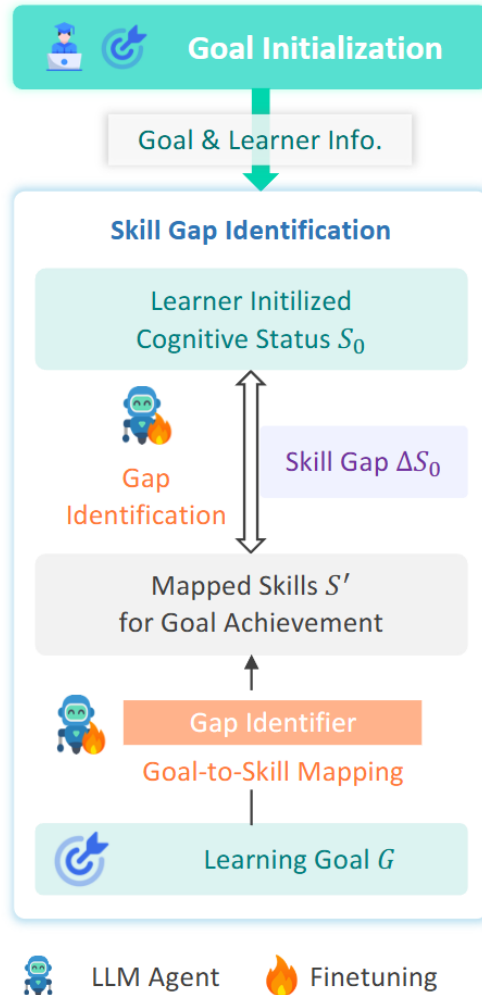


Skill Gap Identification	Identifies the skills gap between the learner's current knowledge and the skills required to achieve their goals	Necessity Completeness
Adaptive Learner Modeling	Continuously update learner profiles by incorporating interaction data to track dynamic learner's status	Comprehensiveness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

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



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



Challenges in Skill Gap Identification

Ambiguity in Goals

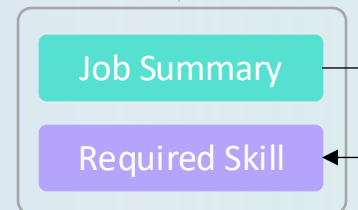
Goals are often high-level or abstract, making them hard to map directly to skills

Unnecessary or incomplete Skills

Direct prompt engineering might include redundant or incomplete skills

Goal-to-Skill Dataset Construction

Job Posting Dataset



CoT-enabled Reasoning Track Completion

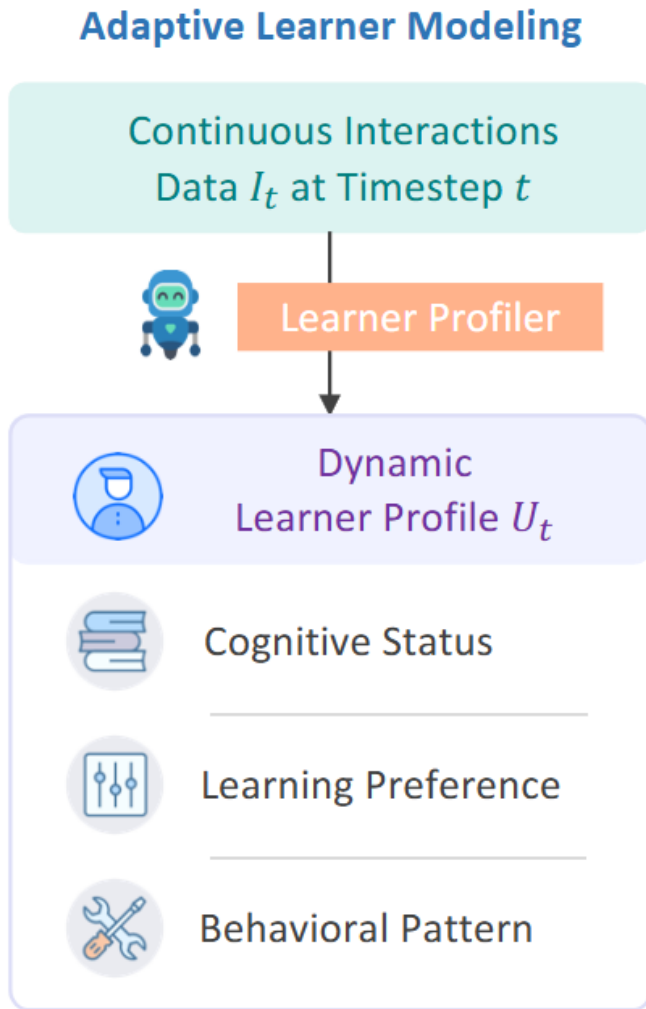
Gap Identification Process

Maps the learning goal to required skills

Assess learner's current skills and level

Identify the skill gap for goal achievement

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.

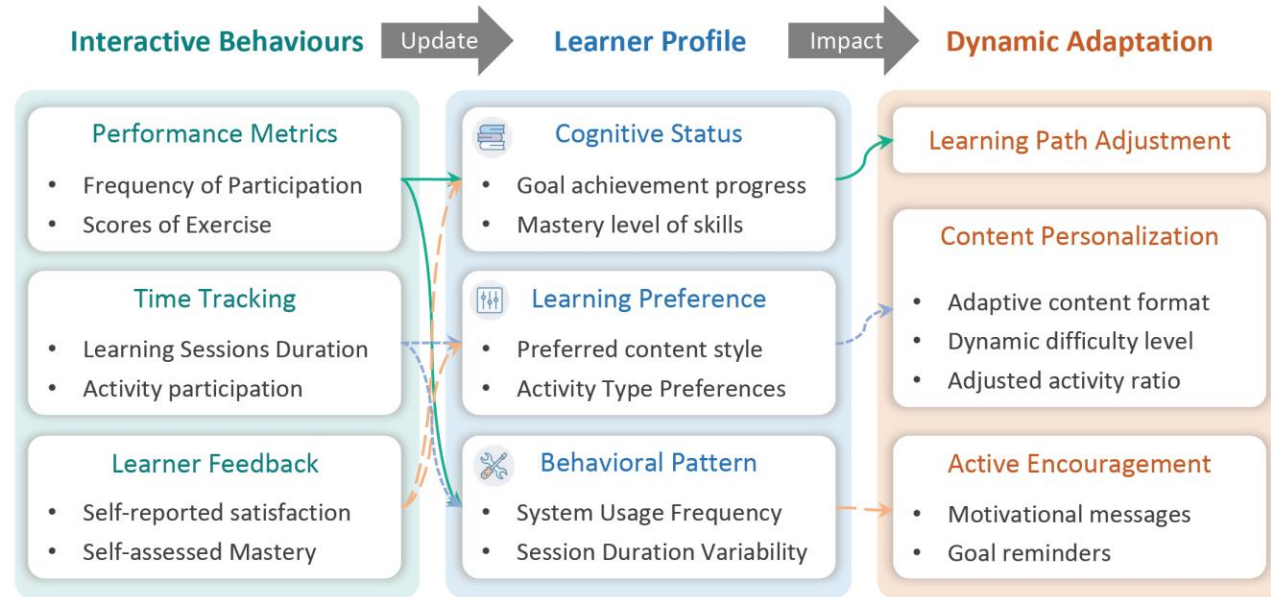
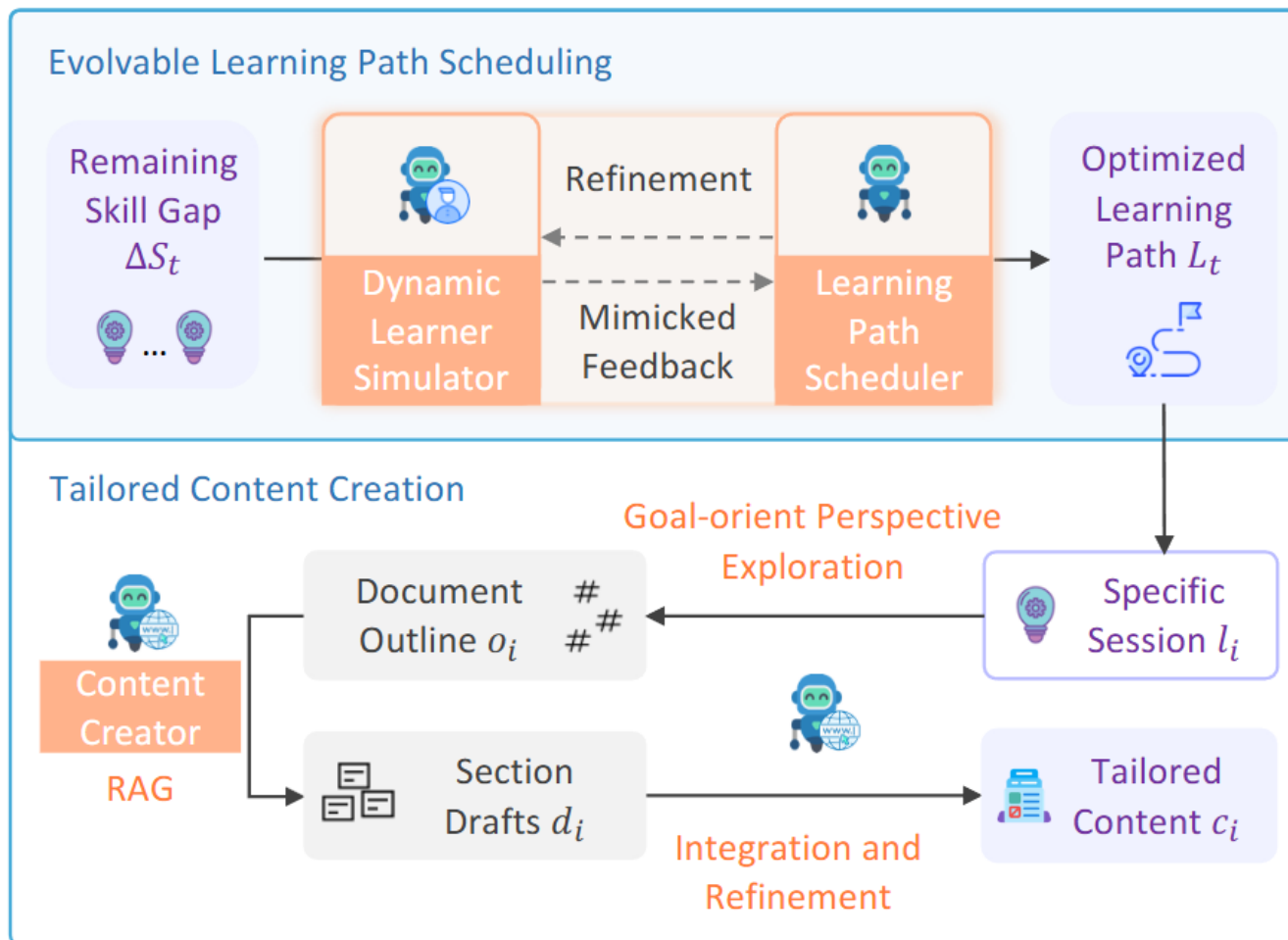


Figure 3: An illustration of dynamic learner modeling.

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

Personalized Resource Delivery



Learner Simulator

Mimics learner feedback to refine

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

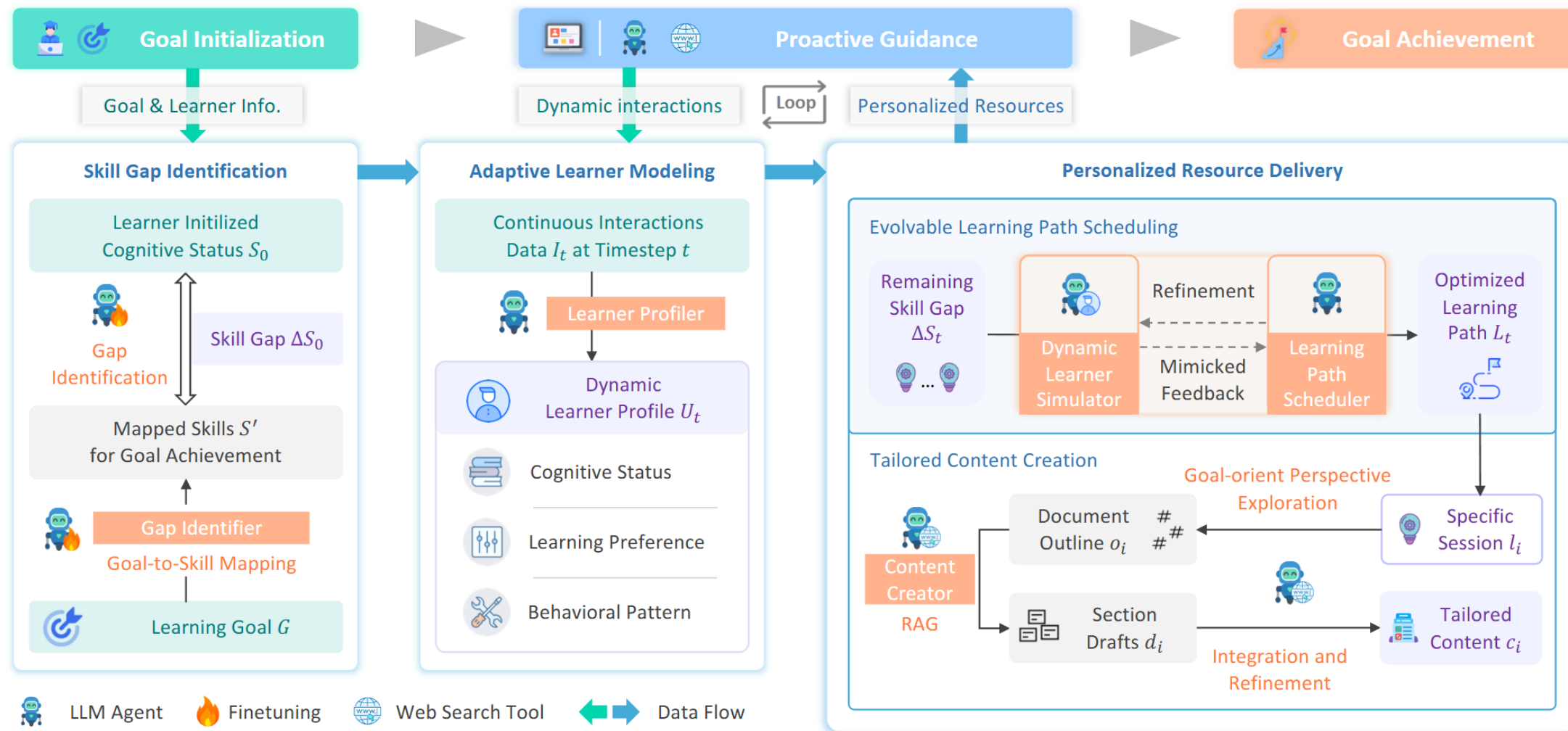
Goal
Relevance

Content
Quality

Personalization

Engagement

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



Leverage LLMs to evaluate the system's performance on key outputs

Implementation

LLMs Used:

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

Web Tool:

Bing Search

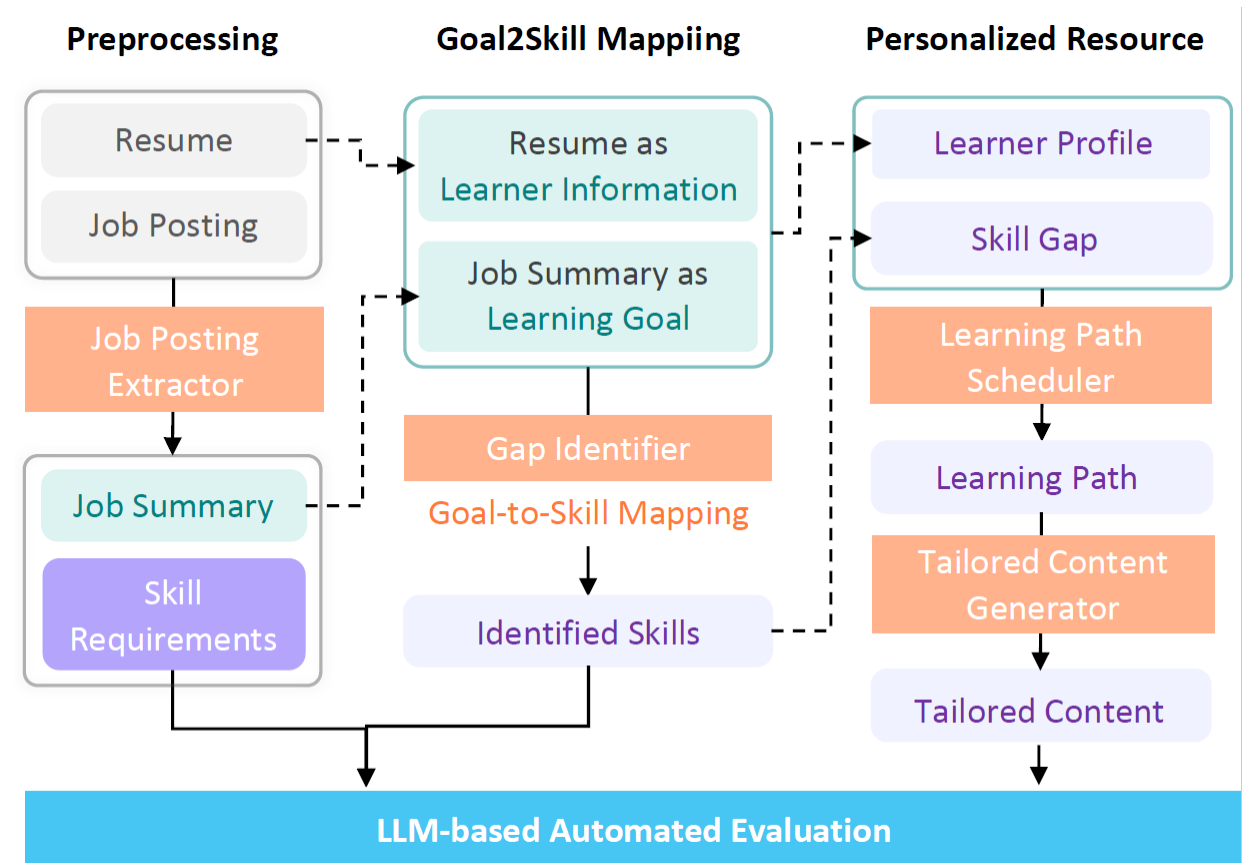
Fine-Tuning:

Azure AI Studio

RAG Embedding:

Text-embedding-3-small

LLM-based Automated Evaluation



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

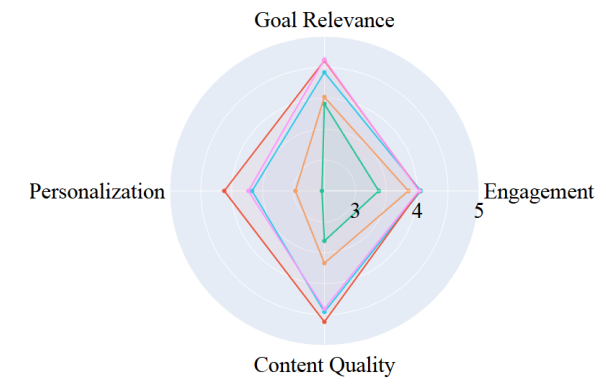
B. Evaluating Learning Path

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

DirGen RAG OutlineRAG
GenMentor w/o Refinement



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.

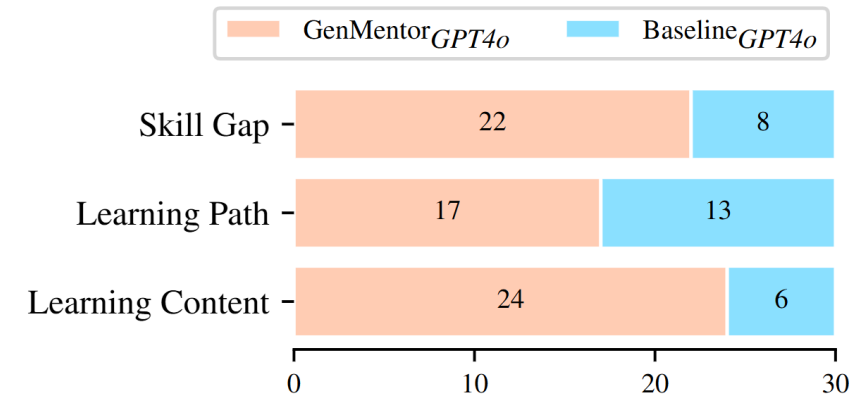


Figure 5: Human comparative preference.

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).

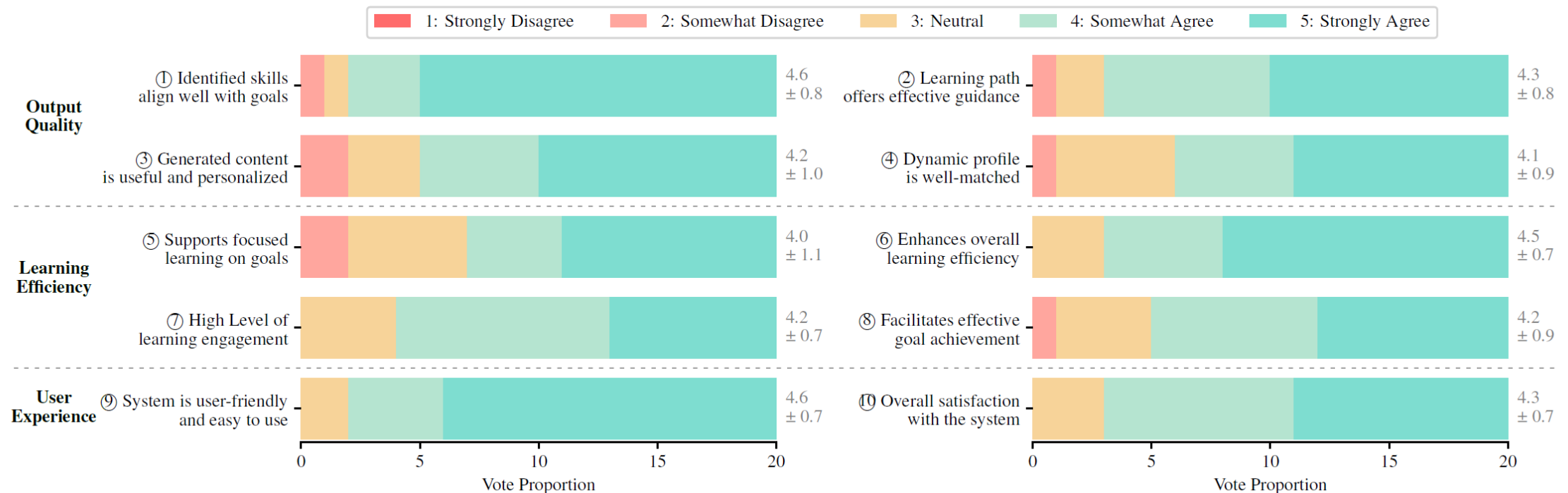


Figure 6: Questionnaire results from 20 participants (questions shortened for clarity). Gray texts are means and std. deviations.



GPT-4o



Onboarding GenMentor

Start Your Goal-oriented and Personalized Learning Journey!

Set Learning Goal

Please enter your role and specific learning goal. You can also refine it with AI suggestions.

*Enter your learning goal

I would like to build a goal-oriented learning intelligent tutoring system based on LLM-powered multiagent system.

AI Refinement

Share Your Information

Please provide your information (Text or PDF) to enhance personalized experience

* Select your occupation

AI Researcher



[Optional] Upload a PDF with your information (e.g., resume)



Drag and drop file here
Limit 200MB per file • PDF

Browse files



tianfuwang_cv (8).pdf 53.8KB




[Optional] Enter your learning preferences and style


Save & Continue

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GPT-4o



Skill Gap

Review and confirm your skill gaps.

There are 10 skills in total, with 10 skill gaps identified.

1. LLM (Large Language Model) expertise

Required Level

unlearned beginner intermediate **advanced**

Current Level

unlearned beginner intermediate advanced

More Analysis Details

☒ Mark as Gap

2. Multi-agent system design

Required Level

unlearned beginner intermediate **advanced**

Current Level

unlearned beginner intermediate advanced

More Analysis Details

☒ Mark as Gap

3. Software development

Required Level

unlearned beginner intermediate **advanced**

Current Level

unlearned beginner intermediate advanced

More Analysis Details

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GenMentor

Goal Management

Learning Path

Resume Learning

My Profile

Analytics Dashboard

Learning Path

Track your learning progress through the sessions below.

Current Goal

In-progress Goal

I would like to build a goal-oriented learning intelligent tutoring system based on LLM-powered multiagent system.

Overall Progress

0/8 sessions completed (0%)

Keep going! You're making great progress.

View Skill Details

Learning Sessions

Re-schedule Learning Path

1: Introduction to LLMs

View Session Details

Keep Learning

Learning

3: Basics of Software Development

View Session Details

Keep Learning

Learning

5: User Experience (UX) Design Principles

2: Understanding Multi-Agent Systems

View Session Details

Keep Learning

Learning

4: System Architecture Fundamentals

View Session Details

Keep Learning

Learning

6: Machine Learning Principles

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← Back

🔄 Regenerate

✅ Complete Session

Session 1

Introduction to LLMs

This session provides an overview of Large Language Models (LLMs), covering their architecture, functionality, and applications in AI research. Learners will engage in interactive exercises to grasp foundational concepts.

Associated Skills:

- LLM (Large Language Model) expertise

Stage 1/4 🧠 Knowledge points explored successfully.

View Explored Knowledge Points

Stage 2/4 📝 Knowledge points drafted successfully.

Stage 3/4 📄 Knowledge document integrated successfully.

○ Stage 4/4 - Generating document quizzes...

○ Running `generate_document_quizzes(...)`.

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Goal Management

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Analytics Dashboard

Document Structure

1. Foundational Concepts

1.1. Overview of Large Language Models (LLMs)

1.2. Architecture of LLMs: Transformers and Attention Mechanism

1.3. Common Applications of LLMs in AI

2. Practical Applications

2.1. Practical Implementation of LLMs: Tools and Frameworks

2.2. Example Implementation

2.3. Key Considerations

2.4. Reflection Questions

2.5. Additional Resources

2.6. Evaluating LLM Performance: Metrics and Benchmarks

2.7. Ethical Considerations in LLM Development

3. Strategic Insights

3.1. Integrating LLMs into Multi-

← Back

↺ Regenerate

✔ Complete Session

Session 1

Introduction to LLMs

This session provides an overview of Large Language Models (LLMs), covering their architecture, functionality, and applications in AI research. Learners will engage in interactive exercises to grasp foundational concepts.

Associated Skills:

- LLM (Large Language Model) expertise

Integrated Document on Introduction to LLMs

This document provides a comprehensive overview of Large Language Models (LLMs), covering their architecture, functionality, and applications in AI research. Designed for Tianfu Wang, an AI researcher pursuing a Ph.D., the insights presented here align with the learner's goal of building a goal-oriented intelligent tutoring system powered by LLMs. The content is structured to enhance understanding through interactive exercises and practical applications, catering to Tianfu's preference for engaging and practical learning experiences.

Foundational Concepts

Overview of Large Language Models (LLMs)

Large Language Models (LLMs) are powerful AI systems designed to understand and generate human language. As an AI researcher pursuing a Ph.D., grasping the foundational concepts of LLMs is crucial for your goal of building a goal-oriented intelligent tutoring system.

LLMs leverage vast amounts of data and advanced neural network architectures to perform a wide array of language-related tasks. They have gained popularity due to their ability to generate coherent and contextually relevant text, making them pivotal in various applications within AI research.

Key Characteristics of LLMs:

- Training on Massive Datasets:** LLMs are trained on extensive corpora, allowing them to learn grammar, semantics, and contextual relationships through techniques like self-supervised learning.
- Transformer Architecture:** Most LLMs are based on the transformer architecture, which utilizes mechanisms like attention to focus on relevant parts of the input data, enabling sophisticated language processing.
- Generative Capabilities:** These models can generate text, translate languages, summarize documents, and even assist in creative tasks such as writing and coding.

Applications of LLMs:

- Natural Language Understanding (NLU):** Understanding and interpreting human language.
- Content Generation:** Creating articles, stories, and more.
- Machine Translation:** Translating text between languages.
- Summarization:** Condensing long pieces of text into shorter summaries.
- Conversational Agents:** Powering chatbots and virtual assistants that interact with users in natural language.

Practical Example: Consider using an LLM like GPT-3 in your tutoring system. By integrating it, you can create an interactive learning environment where students ask questions and receive detailed explanations, enhancing their engagement and understanding.

Reflection Questions:

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Learning Path

Track your learning progress through the sessions below.

Current Goal

In-progress Goal

I would like to build a goal-oriented learning intelligent tutoring system based on LLM-powered multiagent system.

Overall Progress

0/8 sessions completed (0%)

Keep going! You're making great progress.

View Skill Details

Learning Sessions

Re-schedule Learning Path

1: Introduction to LLMs

View Session Details

Keep Learning

Learning

3: Basics of Software Development

View Session Details

Keep Learning

Learning

5: User Experience (UX) Design Principles

2: Understanding Multi-Agent Systems

View Session Details

Keep Learning

Learning

4: System Architecture Fundamentals

View Session Details

Keep Learning

Learning

6: Machine Learning Principles

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Goal Management

Learning Path

Resume Learning

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Analytics Dashboard

Learner Profile

An overview of the learner's background, goals, progress, preferences, and behavioral patterns.

Learner Information

Tianfu Wang is an AI researcher with a strong academic background, currently pursuing a Ph.D. in AI. The learner's experience with LLMs and interest in multi-agent systems aligns with the learning goal of creating a goal-oriented intelligent tutoring system.

Learning Goal

I would like to build a goal-oriented learning intelligent tutoring system based on LLM-powered multiagent system.

Cognitive Status

Overall Progress:

0% completed

Mastered Skills:

Skills In Progress:

LLM (Large Language Model) expertise
Required Level: Advanced
Current Level: Unlearned

Multi-agent system design
Required Level: Advanced
Current Level: Unlearned

Software development
Required Level: Advanced
Current Level: Unlearned

System architecture knowledge
Required Level: Advanced
Current Level: Unlearned

User experience (UX) design
Required Level: Intermediate
Current Level: Unlearned

Machine learning principles
Required Level: Intermediate
Current Level: Unlearned

Project management skills
Required Level: Intermediate
Current Level: Unlearned

Data analysis skills
Required Level: Intermediate
Current Level: Unlearned

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Goal Management

Learning Path

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My Profile

Analytics Dashboard

Learning Analytics

Track your learning progress and view learning insights here.

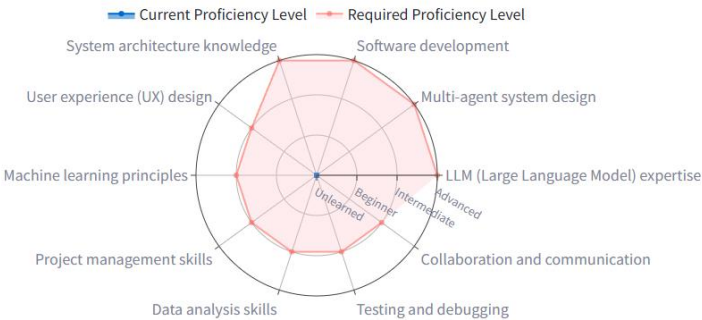
Learning Progress

View the learning progress for each session.

Overall Progress: 0.00%

Proficiency Levels for Different Skills

You have mastered 0 skills and are currently learning 10 skills.



Session Learning Timeseries

View the learning progress over time.

Time

0

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LLM-powered & Goal-oriented Tutoring System

Tianfu Wang¹, Yi Zhan², Jianxun Lian³, Zhengyu Hu¹, Nicholas Jing Yuan^{2,†}, Qi Zhang², Xing Xie³, Hui Xiong^{1,†}

¹Hong Kong University of Science and Technology (Guangzhou) ²Microsoft Inc. ³Microsoft Research Asia

[†]Indicates Corresponding Authors

WWW 2025 (Industry Track) Oral

Thanks!

Welcome to visit our project homepage for more details!

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

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