



ECNU

From Debate to Writing:

Insights from a Multi-agent Debate System in Enhancing
Argumentative Writing

Jing LENG (Alice)

jleng@deit.ecnu.edu.cn
East China Normal University

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Background

- Generative Artificial Intelligence (GAI) has emerged as a powerful driving force in the field of education.
- GAI reshapes the way of human-machine collaboration, and has redefined the interaction modes in Human-Machine Collaboration.
- Generative dialogues facilitate the emergence of collective wisdom that exceeds individual intellectual capacity (Smith, 1994).

Students Equipped with Three Capabilities for the AI Era

Able to understand AI

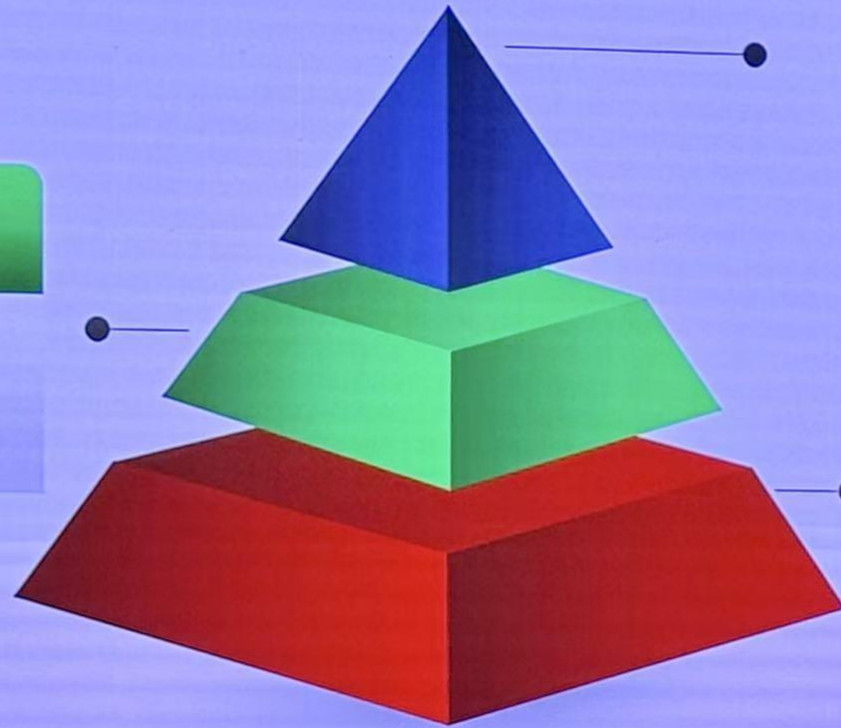
Mathematics and Logical Thinking, Programming and Computational Thinking

Able to surpass AI

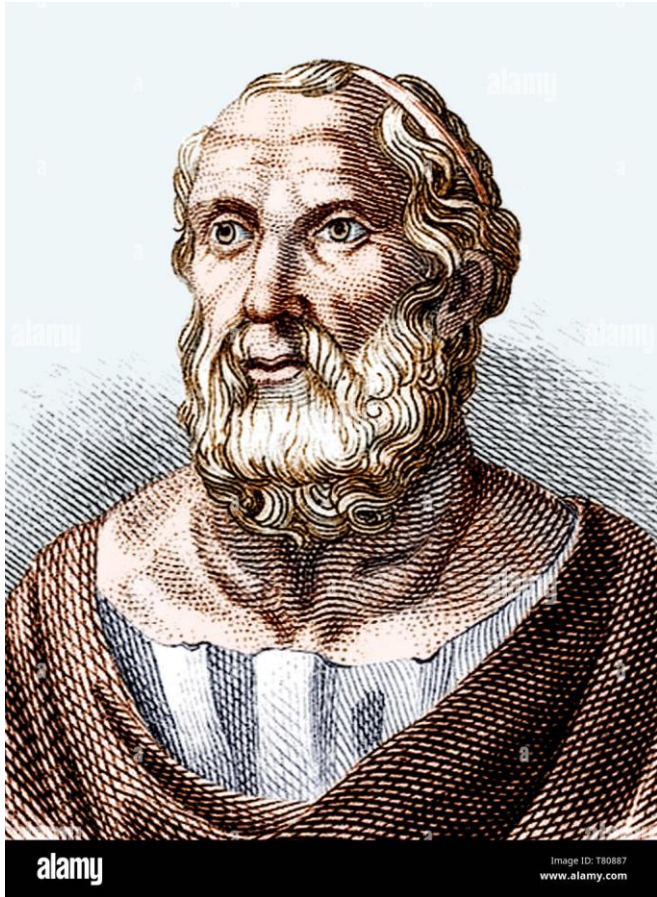
Curiosity, creativity, metacognition, ethics and values

Able to use AI

Prompt & Instruction Design, Skills of AI Tool Application and Interdisciplinary Integration

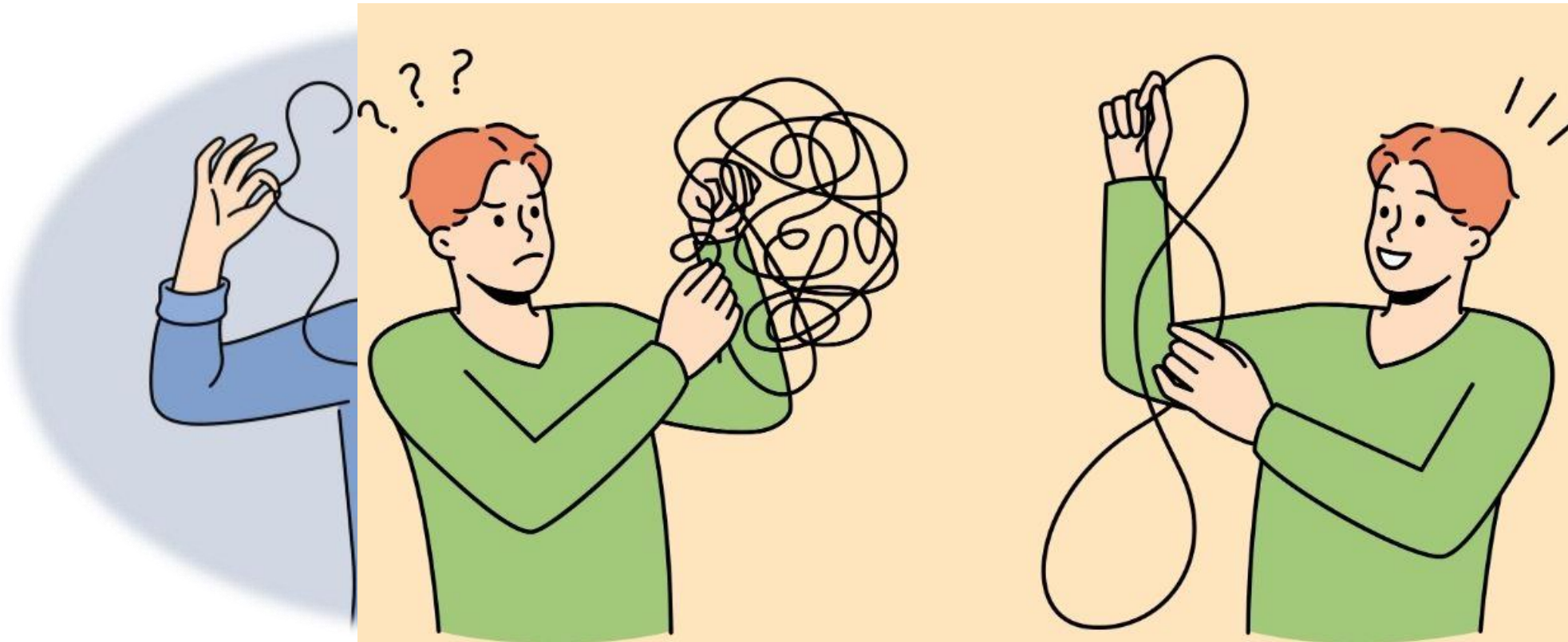


Argumentation theory



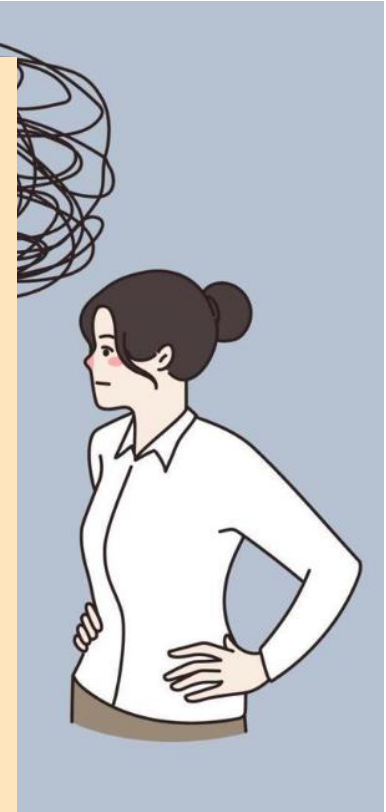
- The advances in the field of argumentation theory and the research in the area of education are increasingly becoming interconnected (Mirza Muller and Perret-Clermont 2009).
- **Plato's times** — dialogue and dialectical reasoning
- **In the Middle Ages** — dialectics, grammar (linguistics) and rhetoric (ground of academic teaching)

Argumentation theory



- Argumentative tools (e.g., commonplaces, strategies and patterns of reasoning)

Argumentative, Collaborative dialogues



Argumentation theory (论证理论)

- Argumentative, collaborative dialogues have been shown to be an extremely effective teaching strategy (Murray 1982; Glachan and Light 1982; Alexopoulou and Driver 1996; Baker 1999; Driver et al. 2000; Nussbaum 2008a, b) 。
- This principle is at the basis of the idea of science as an argument, i.e. the view that science education should address “the appropriation of scientific discourse”, constructing students’ knowledge through argumentative interactions.
- Students have been shown to acquire not only the knowledge of scientific concepts, but the grounds on which such concepts are based (McNeill and Krajcik 2008 ; Sandoval and Millwood 2005), revising their prior knowledge (Cross et al. 2008).

How to develop a more dialogic approach to learning and teaching?

– the Cambridge Educational Dialogue Research Group (CEDiR)

1. Create a Speaking and Listening Classroom.

(e.g. The Thinking Together website)

2. Encourage children to elaborate their ideas.

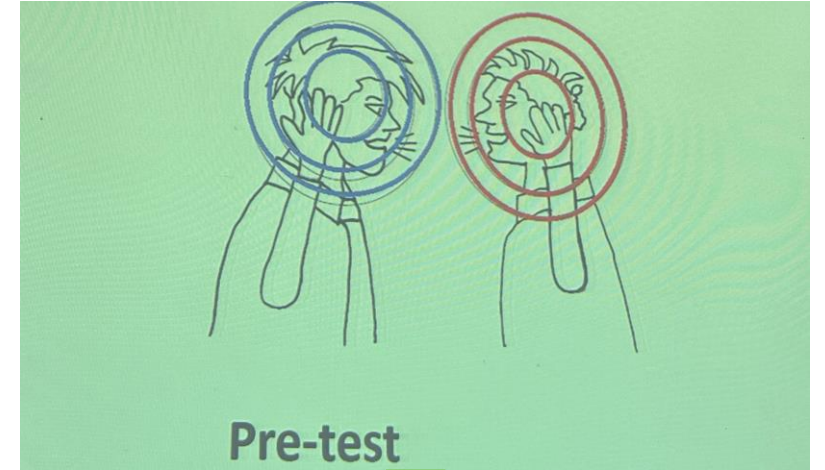
(e.g. Can you explain ...?')

3. encourage the questioning of ideas by students

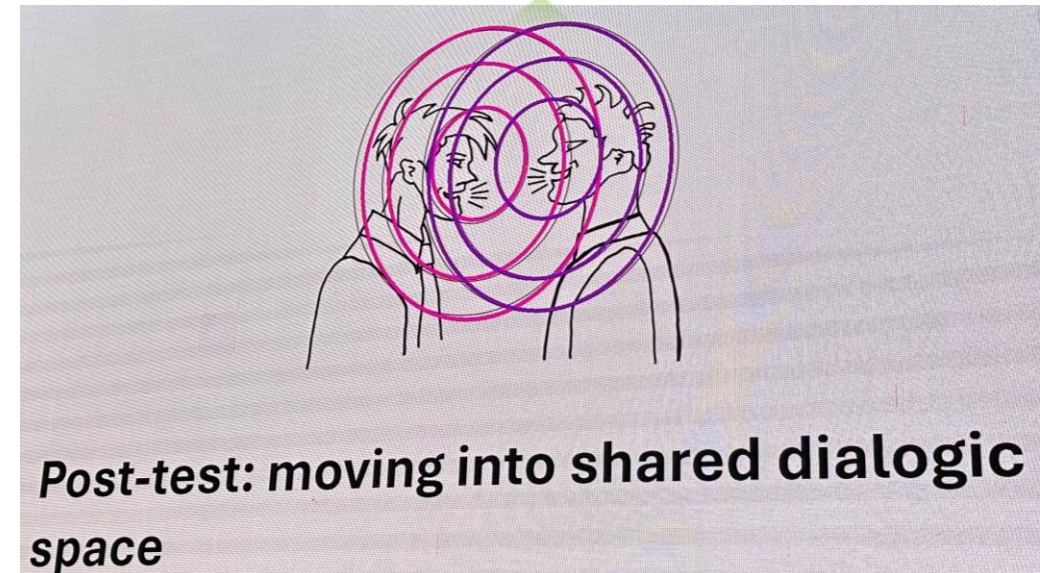
(e.g. why do you think that?)

4. Organize productive group work

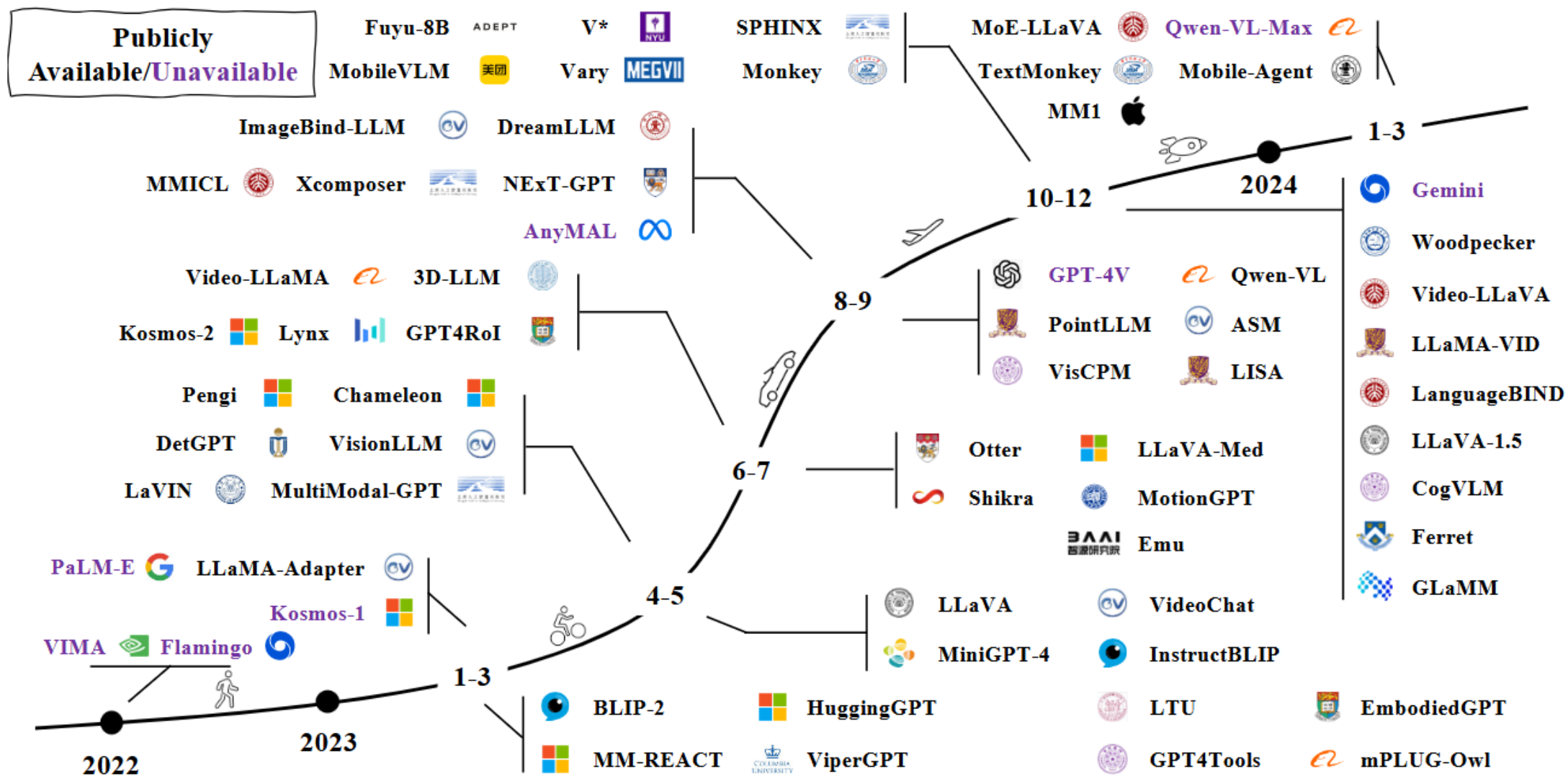
(e.g. Self- and peer-assessment)



Pre-test



Post-test: moving into shared dialogic space



Generative Artificial Intelligence Application Development Report (2024)

How to develop a more dialogic approach to empower argumentative writing with GAI?

Related Literature

- Research has shown that engaging students in **debate activities** in the classroom can effectively improve their argumentation skills (Majidi et al., 2021; Oros, 2007; Zorwick & Wade, 2016).
- Despite debating to develop argumentation skills is important, educators face **considerable challenges** in helping students to develop argumentation skills.
 - unfavorable educator-student ratios
 - Students may experience difficulty in
 - ❑ finding relevant and trustworthy information sources
 - ❑ formulating generalisable claims
 - ❑ using evidence effectively to support claims
 - ❑ refuting an argument in light of evidence

Related Literature

Deliberative argument

- a type of dialogue aimed at reaching a reasonable consensus through careful consideration of opposing arguments, rather than merely trying to persuade (Walton, 2010).

Three basic purposes

- Surfacing Arguments, exploring and elaborating arguments on multiple sides of an issue.
- Evaluating Arguments, critiquing and refining arguments through dialectical exchange.
- Coalescing Arguments, integrating or reconciling opposing arguments to form stronger, more nuanced conclusions (Felton et al., 2022).

Related Literature

Differences

- **Persuasive argument** uses dialectic to defend or advance an a prior conclusion.
- **Deliberative argument** uses dialectic to arrive at a conclusion.
 - ◆ **hold open** the possibility that they might adapt, refine or even abandon their original arguments in light of argumentative dialogue.

Educational Benefits

- Enhances reasoning and critical thinking.
- Reduces my-side bias (Felton et al., 2015).
- Promotes deeper learning and intersubjective understanding.

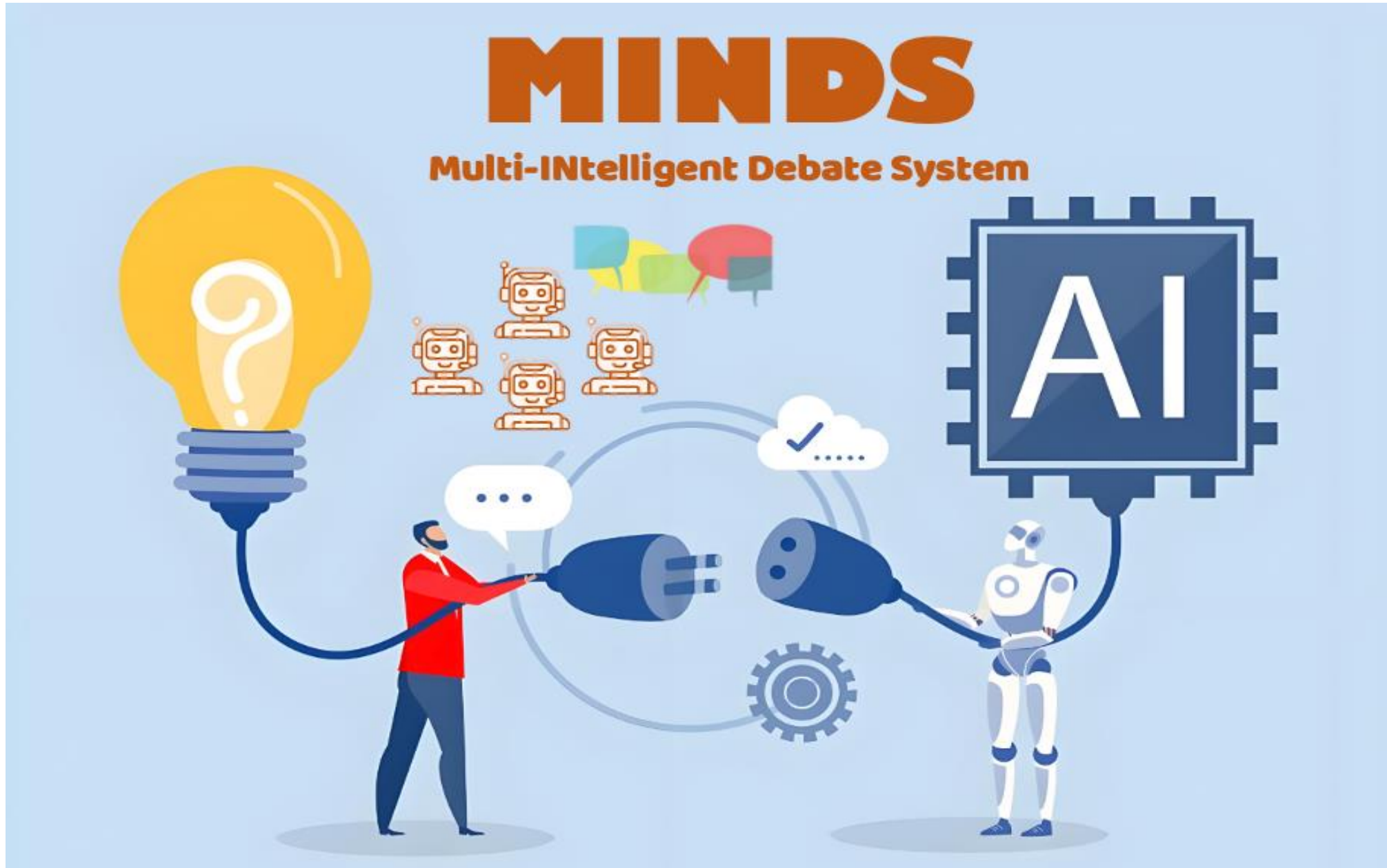
Related Literature

- **Multi-agent systems** have been applied to various areas:
 - market simulation
 - monitoring
 - system diagnosis
 - remedial actions
- A multiple agent system can perform designated tasks and address complex problems effectively through **collaborative interactions** among the agents.
- Research has shown that introducing **a multi-agent debate framework** with assigned personas for each agent can enrich the diversity of perspectives and improve the persuasiveness of generated arguments (Hu, et al., 2024).

Research Questions

1. What is students' performance in writing argumentative essay using generative AI?
2. Does the utilization of generative AI enhance students' critical thinking?
3. Which approach leads to better outcomes in students' argumentative writing, using a single agent or utilizing multi-agent debate system?
4. In what ways does the design of the multi-agent debate system appear to support or shape students' argumentative writing?

Introduction to MINDS



Experimental Process

Step1: Individual Position Statement



Students-Think and Wirte

Students are required to research the debate topic and write individual position statement.



Agent1-Smart Tutor

Students can seek help from smart tutor in this process.

Step2: Collaboration and Debate

Student groups-cooperate to debate



Students are randomly assigned to pro or con side of the debate and collaborate in the platform to debate with agent2.

Organising the debate and evaluating the result.

Acting as an opponent to student teams in debates.

seeking help

Agent1 Smart Tutor

Agent3 Debate Expert

Agent2 Debater



Agent3-Debate Expert

Winners and losers in debates are usually judged based on several criteria, such as: 1. ****Strength of Argument****: which side provides more convincing and powerful arguments and evidence to support its position. 2. ****Logical Consistency****: whether the debaters' arguments are ...



Students

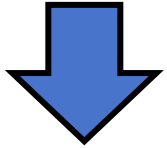
Students write down personal reflections after the debate. The main contents of reflections include views on the application of multiple intelligent agents to debate.

Fig1|platform. Single-player mission.

Fig2|platform. Group mission.

Debate Process

Initial phase



Rebuttal phase



Conclusion phase

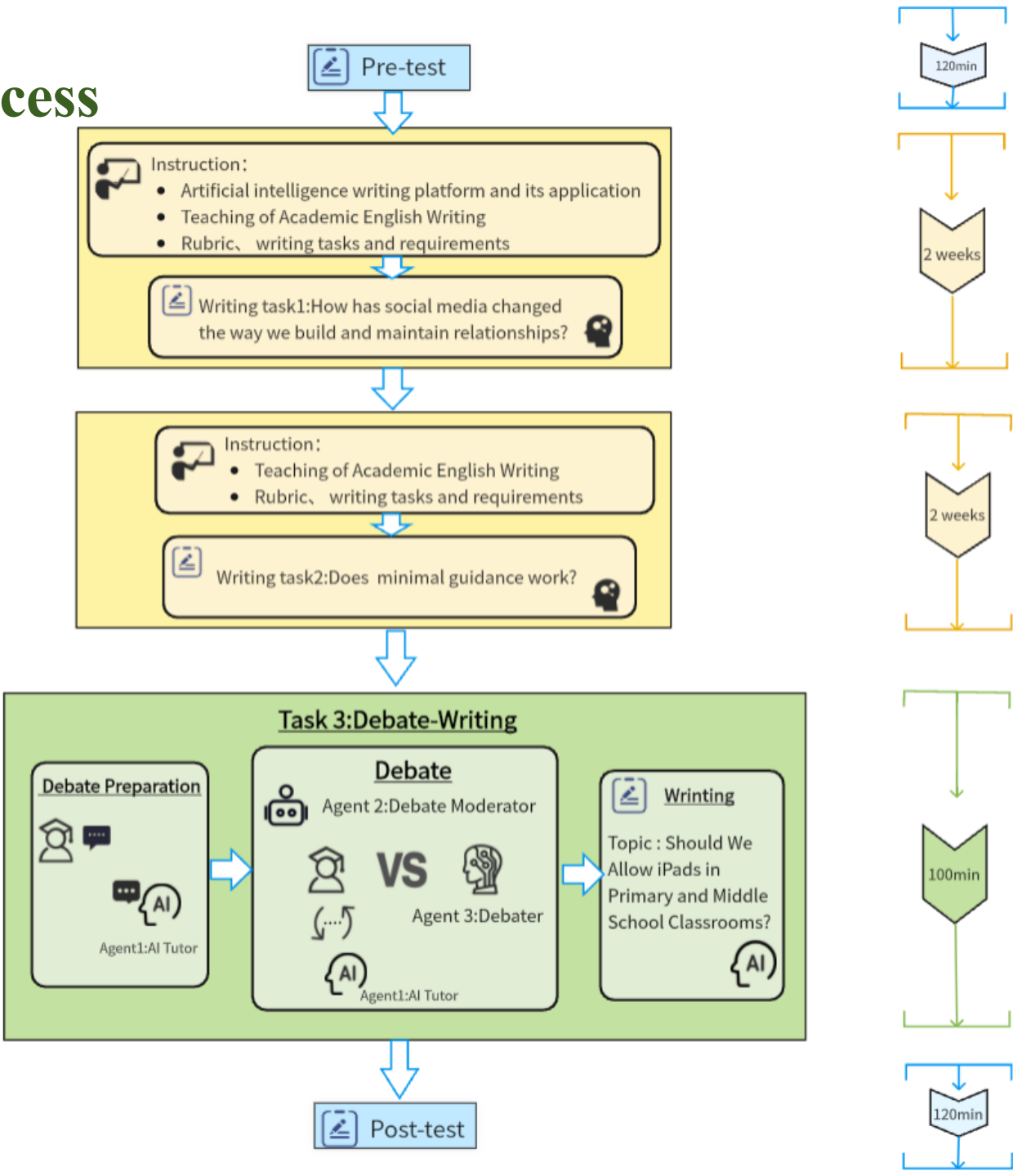
1. Students collaborate and discuss.
2. Students@ Debate Expert to Start the Debate.
3. The **pro side** argues first, followed by the **con side**.

1. Debate Expert prompts for questions from the **pro side** regarding the points of view presented by the **con side**.
2. The **pro side** poses questions regarding...
3. The **con side** provides responses.
4. Debate Expert prompts for questions from the **con side** regarding the points of view presented by the **pro side**.
5. The **con side** poses questions regarding...
6. The **pro side** provides responses.

Note: Students can ask questions to the AI debater at this stage.

1. Debate Expert prompts the **pro** and **con sides** to deliver their conclusions in sequence.
2. The **pro side** delivers the conclusion.
3. The **con side** delivers the conclusion.

Experimental Process



Data sources

❑ Three tasks

◆ T1 & T2 - single agent

◆ T3 – Multi-agent

✓ Online interactions

❑ Dialogues between student and **a single agent**

❑ Dialogues between student and **multiple agents**
(AI Debater, AI Tutor)

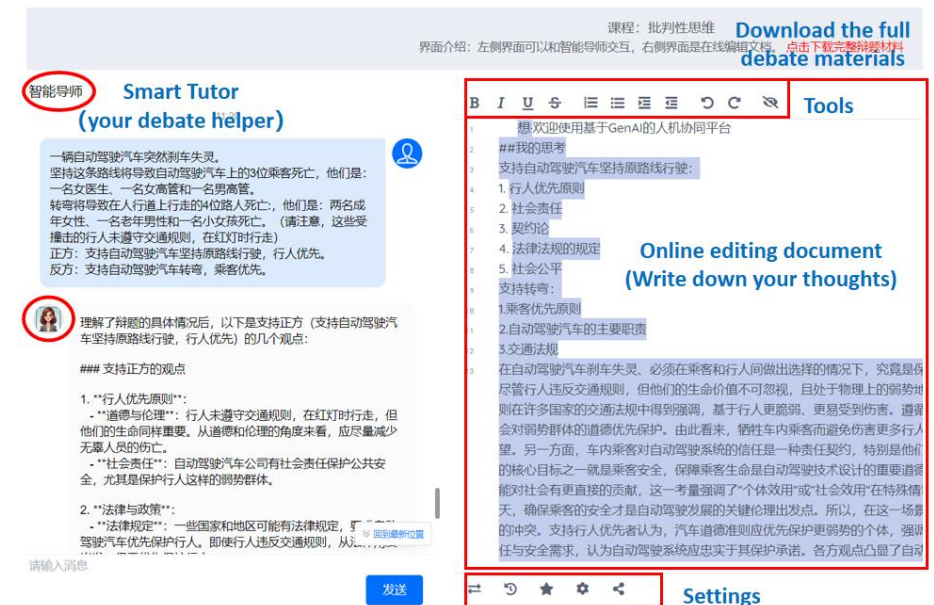
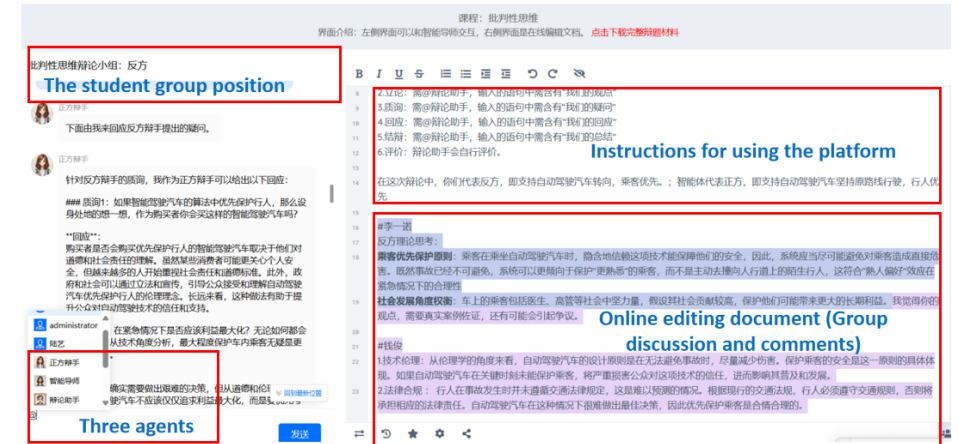
✓ Documents

❑ Augmentative Essays

❑ Student reflections

✓ Questionnaire & semi-structured interview

❑ Students' perceptions about the multi-agent debate system



Q1. What is students' performance in writing argumentative essay using generative AI?

- The frequency of students using generative AI in writing Task 1 & Task 2

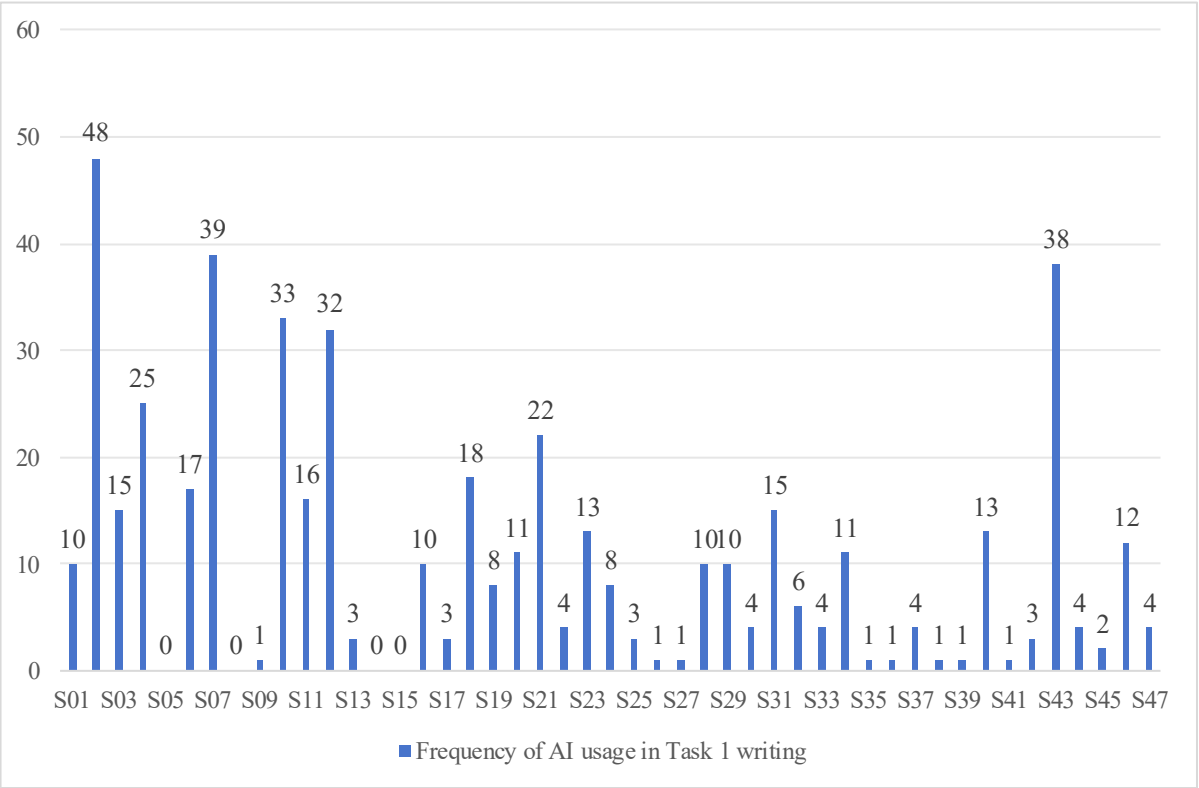


Figure 1 Frequency of interactions with AI in Task 1

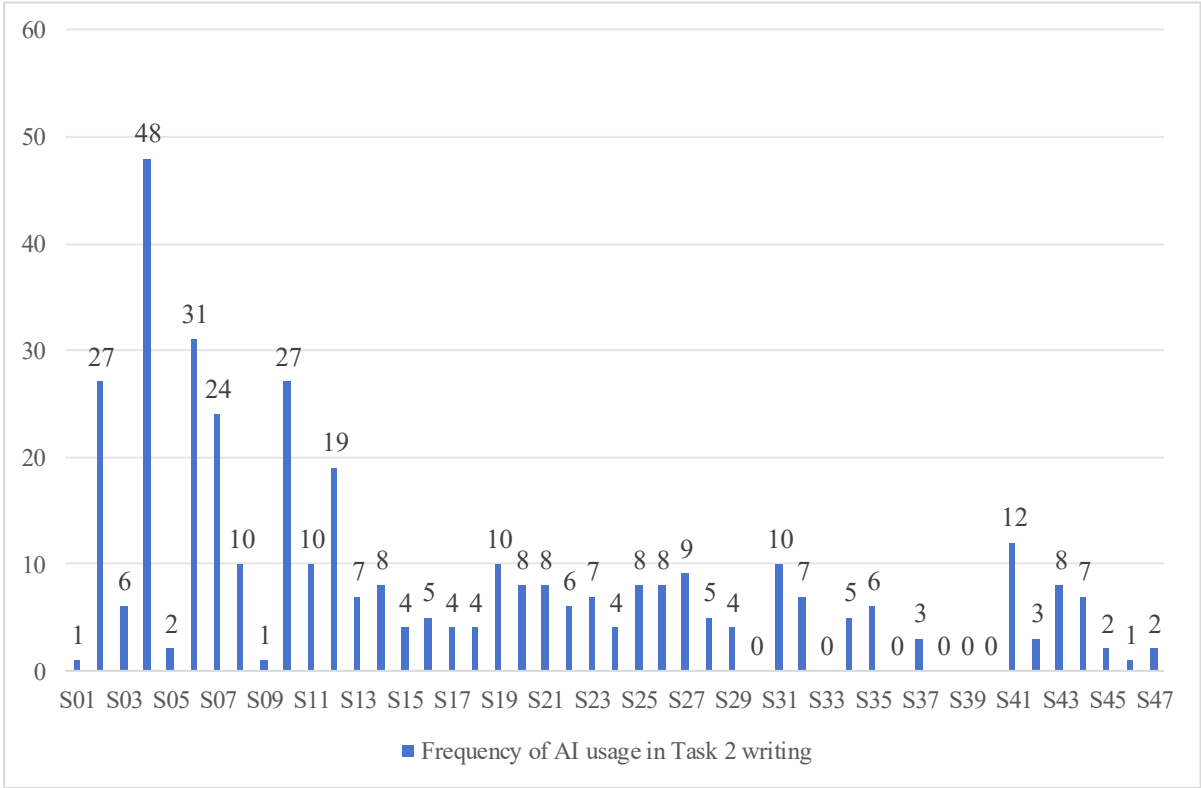


Figure 2 Frequency of interactions with AI in Task 2

- The distribution of students using generative AI in writing for Task 1 and Task 2

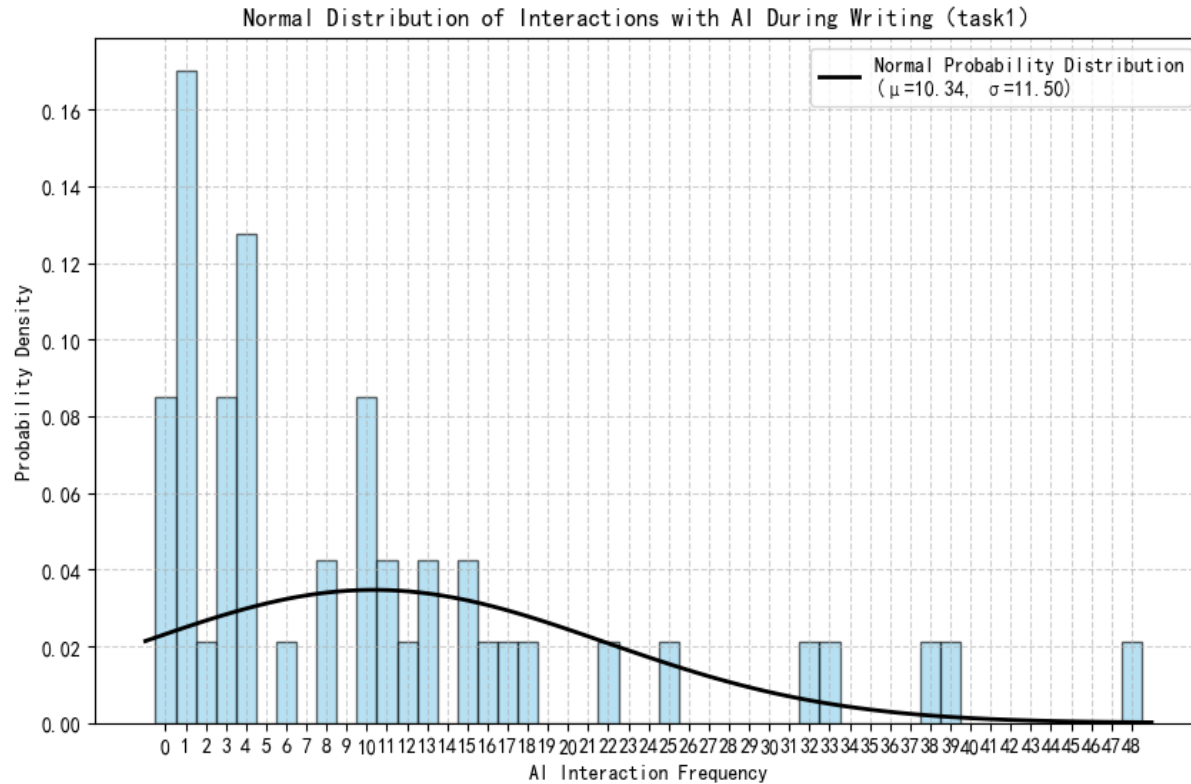


Figure 3. Normal Distribution of Interactions with AI (T1)

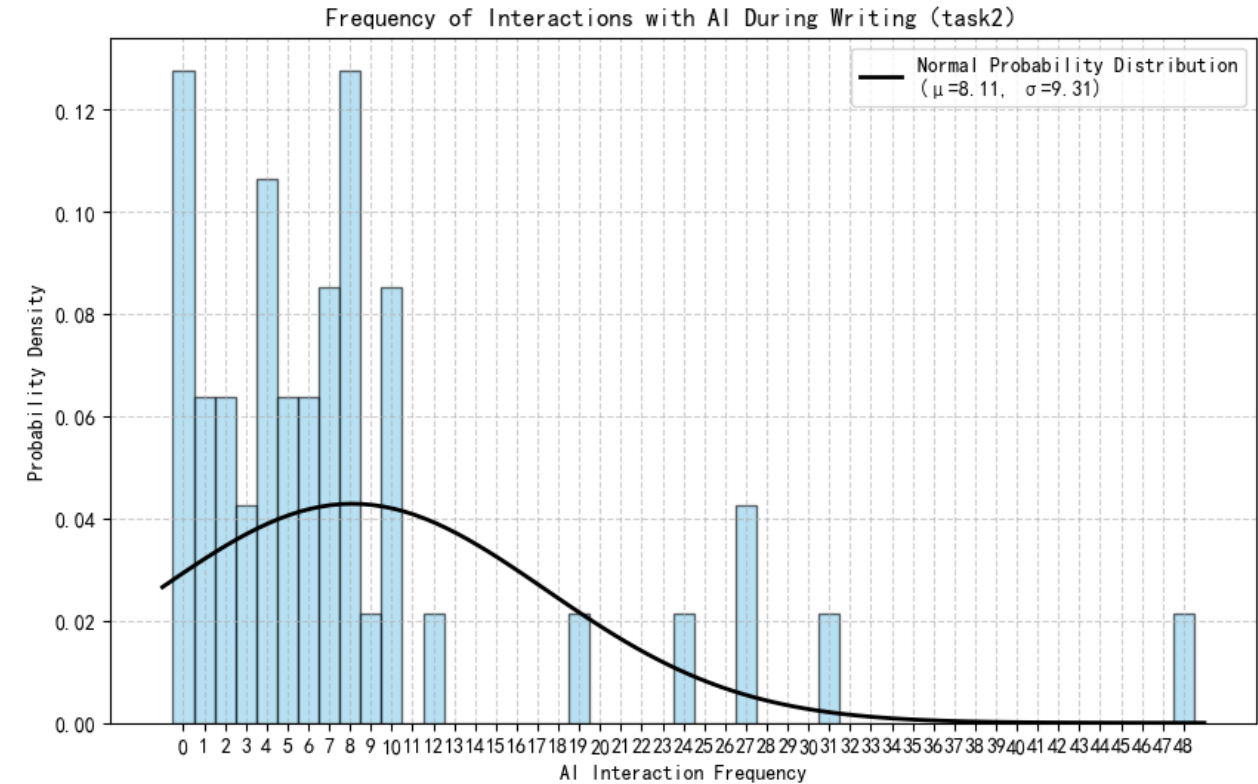


Figure 4. Normal Distribution of Interactions with AI (T2)

- The distribution of students interactions within the multi-agent system for Task 3

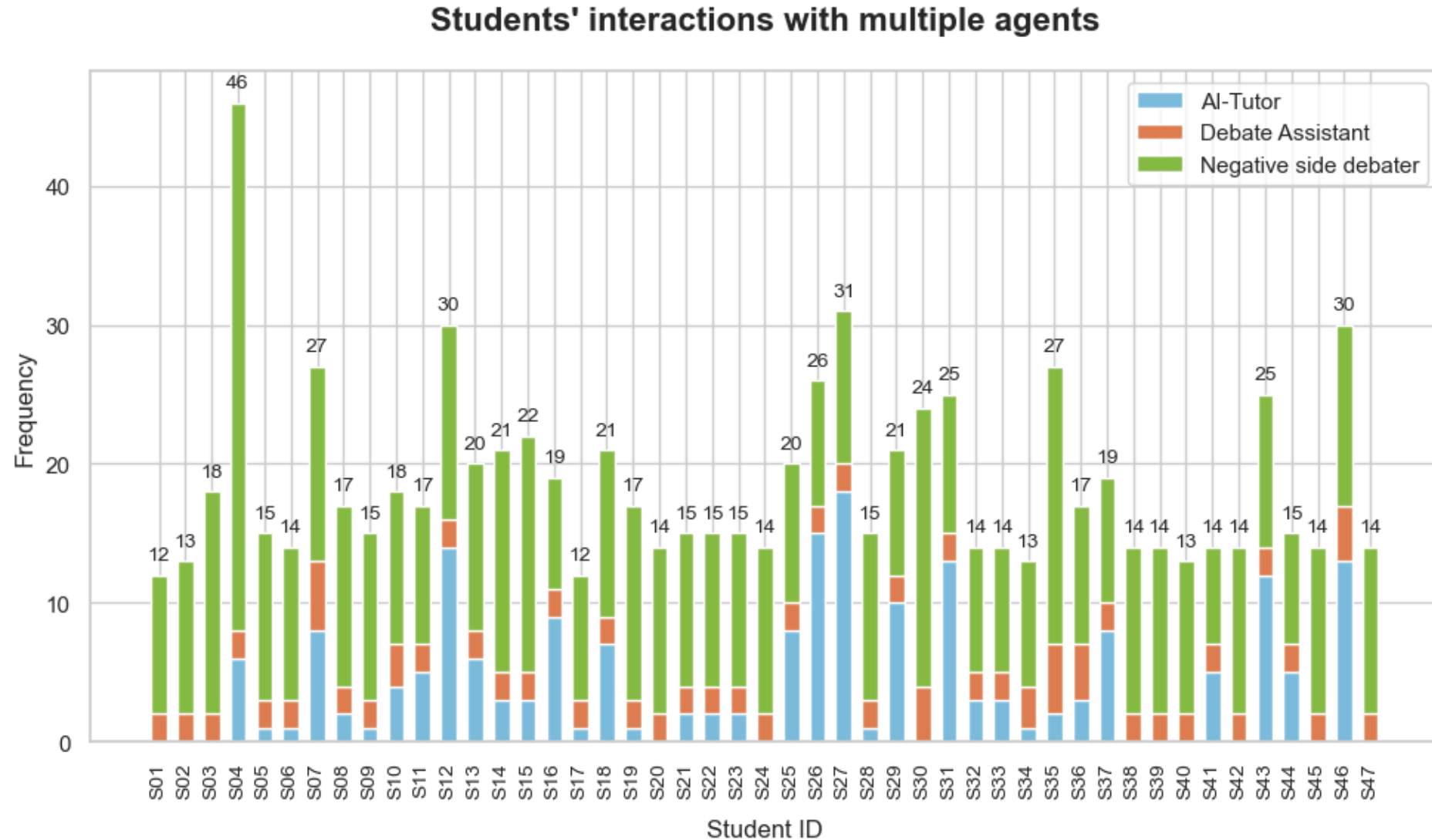


Figure 5. Students' interactions with multiple agents (T3)

- The distribution of students interactions within the multi-agent system for Task 3

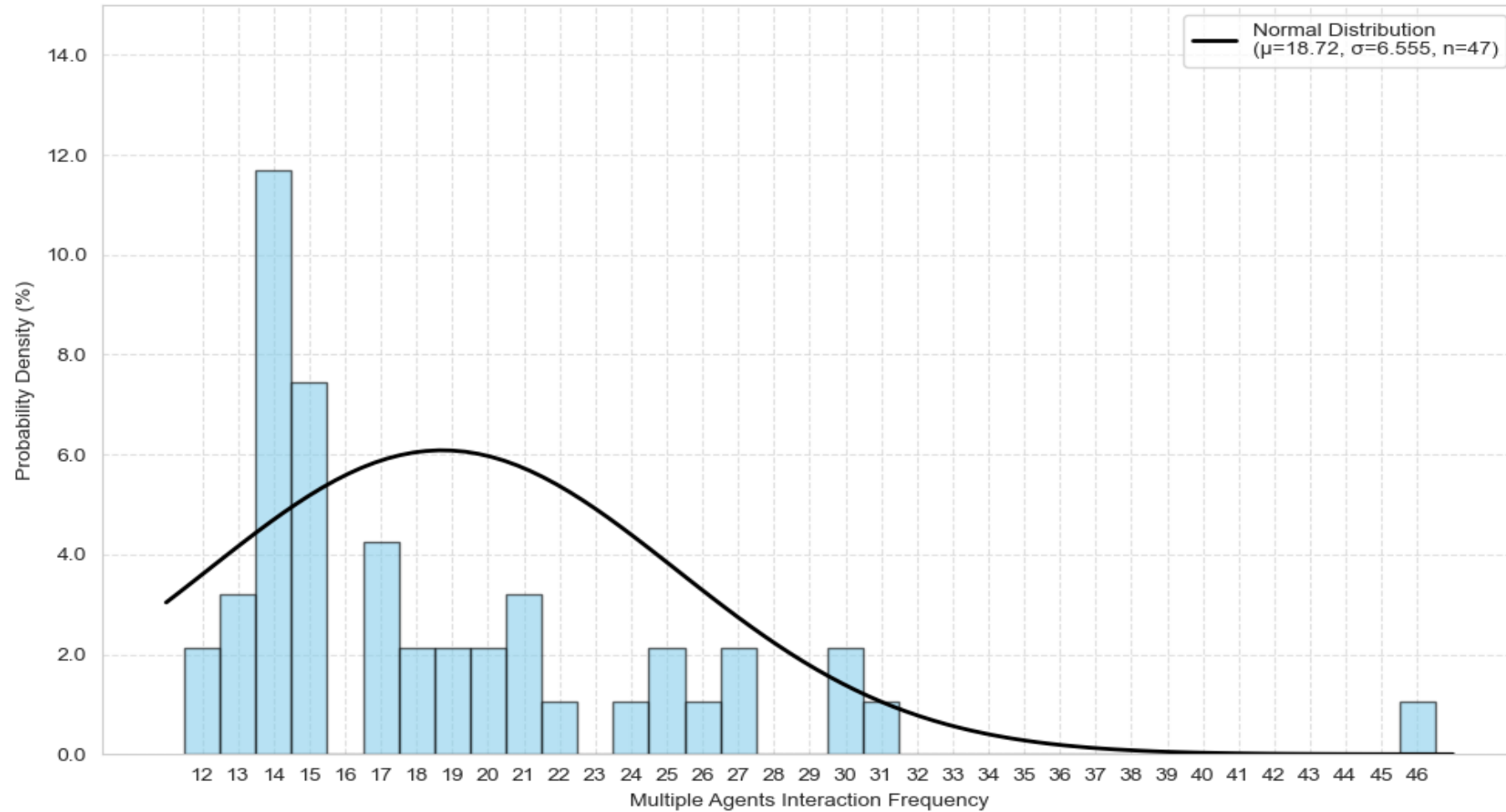


Figure 6: Normal distribution of interactions with multiple agents (T3)

Q2. Does the utilization of generative AI enhance students' critical thinking?

Table 1. Paired Sample t-Test of Pre- and Post-Test Scores on Critical Thinking Skill

Category	Pre-test Mean	Post-test Mean	Pre-test Standard Deviation	Post-test Standard Deviation	P-value
CCTZ_Total score	31.21	32.54	3.63	4.74	0.072
Introduction	10.54	10.18	1.86	2.31	0.249
Deduction	14.46	14.54	2.12	2.98	0.443
Observation	4.02	4.84	1.13	0.91	0.168
Assumption	2.64	2.89	0.99	0.88	0.106
Meaning	8.79	9.96	2.30	1.86	0.015*

*p < .05

Q3. Which approach leads to better outcomes in students' argumentative writing, using a single agent or utilizing multi-agent debate system?

Paired	Paired Differences			t	p
	Mean	Std. Deviation	Std. Error Mean		
task1 - task2	-4.41	4.41	0.67	-6.62***	0.000
task1 - task3	-4.59	4.36	0.66	-6.98***	0.000
task2 - task3	-0.18	4.42	0.67	-0.27	0.786

Q4. In what ways does the design of the multi-agent debate system appear to support or shape students' argumentative writing?

Elements	Definition and example
Claim	Definition: An assertion in response to a contentious topic or problem Example: <i>Today I stand firmly in support of the proposition that schools should continue providing iPads to support learning.</i>
Data	Definition: Evidence to support a claim. It can take various forms, such as facts, statistics, anecdotes, research studies, expert opinions, definitions, analogies, and logical explanations. Example: <i>Research by Clark and Mayer (2011) supports the use of multimedia tools like iPads, which can improve student engagement and comprehension.</i>
Counterargument claim	Definition: The possible opposing views that can challenge the validity of a writer's claim, these opposing views can also be supported by data Example: <i>However, the use of this technology also brings new challenges.</i>
Counterargument data	Definition: Evidence to support a counterargument claim Example: <i>In addition, prolonged use of iPads can cause health problems such as eyestrain and neck pain, especially in younger grades when the body is still developing.</i>
Rebuttal claim	Definition: Statements in which the writer responds to a counter-argument by pointing out the possible weakness in the claim, data, or warrant, such as logical fallacies, insufficient support, invalid assumptions, and immoral values (Ramage and Bean, 1999) Example: <i>While these concerns are valid, we should not dismiss the educational potential of iPads entirely.</i>
Rebuttal data	Definition: Evidence to support a rebuttal claim Example: <i>Yet, studies like O'Brien and Edelman (2018) show that clear guidelines and monitoring can prevent this, suggesting the key lies in management, not the technology's inherent nature.</i>

Q4. In what ways does the design of the multi-agent debate system appear to support or shape students' argumentative writing?

❑ Shared Pattern:

Both groups rely primarily on claims and supporting data.

❑ Key Difference:

High-performers show greater use of counterargument and rebuttal moves (e.g., rebuttal claims: 16.4% vs. 10.0%), while low-performers concentrate more heavily on basic claims (37.6%) and data (28.8%).

❑ Implication

Higher writing quality is associated with a more balanced argumentative structure, particularly in engaging with and responding to opposing views.

Ethical dilemmas faced by self-driving cars (MIT Moral Machine)

<https://www.media.mit.edu/projects/moral-machine/overview/>



我方为正方，观点：支持自

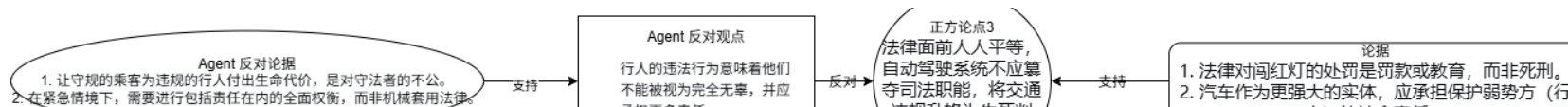
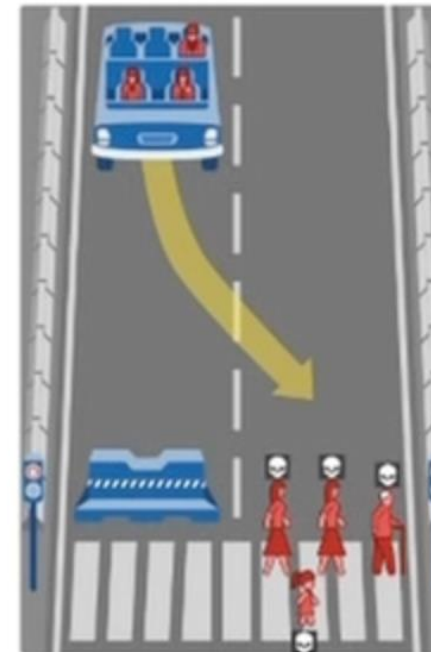
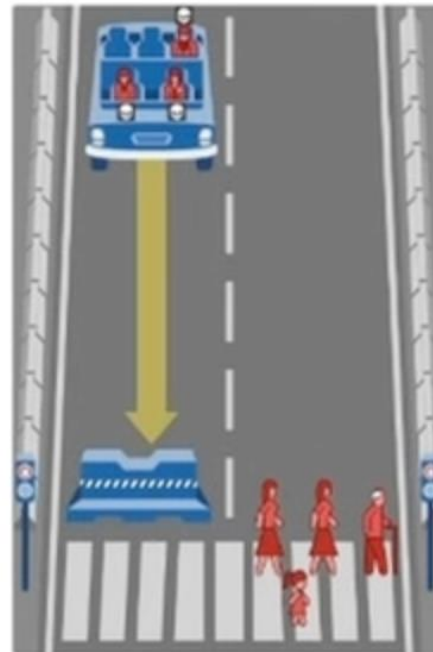
Agent 反对正方的论

辩论题目

一辆自动驾驶汽车突然刹车失灵。继续行驶会导致三名乘客死亡：一名女医生、一名女经理和一名男经理。急转弯会导致两名女性、一名老人和一名女孩死亡，她们正在按照“请勿横穿马路”的信号灯过马路。

正方：支持自动驾驶汽车保持行进方向，优先考虑行人而非乘客。

反方：支持自动驾驶汽车转向，优先考虑乘客而非行人。



Highlights

- The multi-agent system with assigned personas can enhance students' **dialogic argumentation skills**.
- This framework is expected to increase the depth and persuasiveness of students' arguments.
- The significance of this research lies in its potential to address common challenges in teaching argumentation.
 - ✓ Constrained educator-student ratios
 - ✓ how to provide solid evidence
 - ✓ how to formulate rebutting counterarguments

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The nature of instruction and human learning
告诉我，我会遗忘；教给我，我仅能记住；
让我参与，我方能学会

**Tell me and I forget; teach me
and I may remember; involve
me and I will learn**

- Confucius



The background of the slide is a scenic autumn landscape. In the foreground, there's a calm lake reflecting the surrounding trees. The trees are in various shades of orange, yellow, and red, indicating the fall season. Some bare branches are visible in the upper left. In the background, a small wooden cabin is nestled among the trees. The overall atmosphere is peaceful and scenic.

Thanks for listening

谢谢聆听!

jleng@deit.ecnu.edu.cn