WIP: Active Learning through Prompt Engineering and Agentic AI Simulation-A Pilot Project in Computer Networks Education

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***Abstract*—This work-in-progress paper introduces the AIcademic system, an innovative framework employing Agentic AI and Agile methodologies to enhance learning in complex domains such as computer networks. Positioned within the topic of AI and Machine Learning Tools to Enhance Instruction, it aims to revolutionize the learning experience and outcomes for the intricate subject matter. This system emphasizes active, adaptive learning experiences through AI generated or AI improved educational materials with multiple iterations of feedback and improvement cycles. Utilizing fine tuned large language models (LLM), the AIcademic system assembles an interactive AI team, e.g. AIcademic Professor, Student, and Instructional Designer. Each AI agent is uniquely configured with our POISE prompt engineering model to analyze and simulate real-time classroom interactions from multiple viewpoints. Active learning pedagogy is embedded into the system through prompt engineering during the creation of each agent. Agile methodology is employed to organize collaborations of the AI agents for complex task planning and implementation, feedback integration, output continuous improvement, and agent self-enhancement. A suite of AI tools is explored to dynamically create tailored educational materials aligned with the educator's teaching preferences and students' needs. Preliminary results from a pilot implementation of teaching the transport layer in computer networks demonstrated improvements in student engagement and comprehension over previous materials. This AIcademic framework presents a promising and scalable paradigm for AI applications in educational environments. While still under development, this research aims to refine and expand these findings, exploring the full potential of integrating Prompt Engineering and Agentic AI for creating active learning environments across complex technical subjects. The implications extend beyond computer network education, offering a blueprint to redefine teaching and learning in a technology-enhanced era. We invite collaboration from the broader academic community to refine the Agent prompt design, automate AI to AI interactions, assess long term impacts, and explore further applications.**

***Index Terms*—Active Learning, Agentic AI, Prompt Engineering, Human-in-the-Loop, Agile Methodology**

I. Introduction

The abstract nature of complex subjects often set barriers to student engagement and comprehension. For instance, in computer networks education, students grapple with intricate technical concepts, a myriad of acronyms, and complicated processes, not to mention remembering all the knowledge and being able to apply them in challenging practical real-world scenarios. Traditional teaching methods, predominantly relying on lectures and textbooks, struggle to bridge the gap between theoretical concepts and practical applications, and catching up with rapid advancement in technologies.

To assist educators in mitigating those challenges, Artificial Intelligence (AI) tools have been explored in many education applications, including generating educational materials to include the latest technological advancements, developing interactive learning activities, creating multimedia to engage students, and offering adaptive personalized assessments [1] [2]. As in [4], a design approach was outlined with highlighting collaboration between educators and learners to adapt to AI advancements. Specifically, this paper re-conceptualized a problem space for educational design as the design for learning space that integrates the capability approach, value creation, co-creation pedagogy, speculative methods, scenario planning, and Activity-Centred Analysis and Design (ACAD) to facilitate learning.

Another AI educational application, integrating AI with human effort, is employed to co-create educational content, enhancing both the quantity and quality of resources available for learning. In [5], a "learnersourcing" framework is discussed, where AI and human collaboration are central to generating, evaluating, and utilizing educational content. This approach not only streamlines content creation through AI-augmented tools but also engages learners in critically evaluating and applying the content, ensuring educational resources are both of high quality and pedagogically valuable.

The automation of assessment, a critical part in AI educational application, is discussed in [3], which critiques traditional educational assessments while exploring how AI can personalize and enhance assessment practices. It also raises the concern about potential ethical issues.

With the rise of LLMs and their widespread applications, prompt engineering, how to effectively use powerful AI tools becomes a new research focus. This trend is exemplified by the development of frameworks like CO-STAR (Context, Objective, Style, Tone, Audience, and Response) and TIDD-EC (Task, Information, Dos, Don'ts, Examples, and Criteria). CO-STAR offers a structured approach to effectively guide LLMs, while TIDD-EC focuses on providing clear directives to ensure task execution is precise and well-defined [12].

Another advancement in AI content generation is the implementation of the agentic workflow, which substantially improves the one-shot prompting approach. Rather than treating AI as a know-it-all assistant, and directly prompting it to generate the final output, the agentic workflow establishes a collaborative AI team to solve complex tasks. This team, composed of different AI agents, each with specific roles and tasks, collaborates in a series of strategically orchestrated interactions to harvest group intelligence from the AI team and delivers more sophisticated and higher quality outputs. For instance, the reasoning-action (ReAct) model [9], demonstrates that the agentic workflow has significant improvements in AI output, as it incorporates constructive feedback from various perspectives. In particular, multi-agent systems have demonstrated superior performance in scenarios requiring collaboration and multiple execution paths [10], making them well-suited for addressing the intricate and complex challenges in technical education, which normally requires nuanced solutions and adaptive approaches.

While exploring AI as a supportive tool, it is essential to remain cautious about the potential risks, such as privacy concerns and the reinforcement of existing biases discussed in [6]. Rather than serving as a replacement of human educators, AI design should be supervised to create inclusive and effective learning environments. The human-in-the-loop design, discussed in [7], ensures that the generated content is effective, ethical, and responsive to human needs by incorporating human feedback and interactions into the development and operation of AI systems.

In this paper, we introduce the AIcademic system and explore how leveraging AI, particularly through Prompt Engineering and other AI-driven tools, can transform the landscape of technical education. This transformation aims to make learning more accessible, engaging, and effective while considering the Fairness, Accountability, Transparency, and Ethics (FATE) framework. We will present the framework in Section II, which includes the utilization of Agentic AI simulations with an Agile rapid iteration process. Section III focuses on AI Agents prompt design, outlining three core roles: professor, student, and instructional designer. AI tools will be discussed in section IV, followed by a brief summary of the preliminary results in section V, future development in section VI, and the conclusion at the end of the paper.

II. The Framework of the AIcademic System

The AIcademic system, based on the agile framework, utilizes various AI agents to support educators in developing educational materials that facilitate active learning and formative evaluation of the materials, as illustrated in Fig. 1. The agile framework enhances the scalability of the AIcademic system by chunking complex tasks, such as course design, into a list of smaller components known as course backlog, by defining learning objectives, mapping content dependencies, and creating sequential backlog items. Based on the dependencies and educational value of the backlog items, a series of learning units are planned, each comprising lectures with corresponding student activities and assessments. For each learning unit, a subset of course backlog items are selected to form the unit backlog.

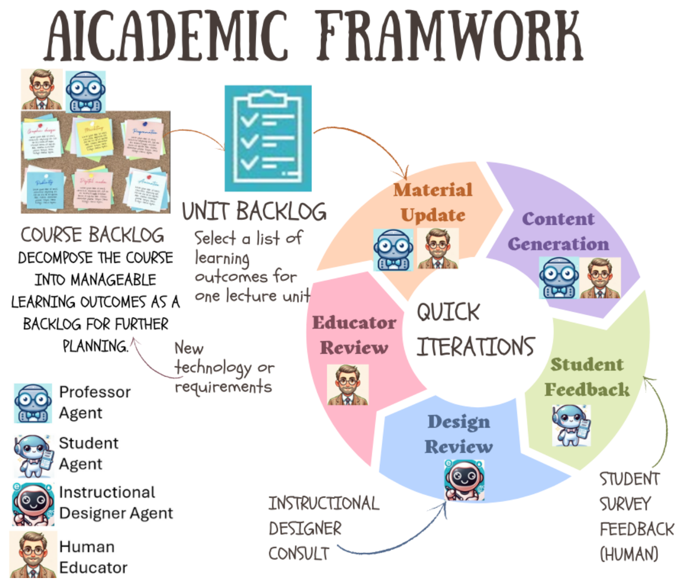

Fig. 1. AIcademic Framework (by Canva and DALL·E 3).

Within the unit backlog, the educator will organize and feed existing educational material and customized information to the Professor Agent. This information may include learner statistics, educator's teaching styles and preferences, and other auxiliary data. Educators can also specify their preferred lecture structures such as the sandwich structure [8], or certain pedagogy such as "Think-Pair-Share". AI will then generate new or enhance existing educational contents, such as pre-lecture reading materials, lecture slides, student activities and handouts, quizzes, and other assessments, for the educator to review.

After the educator's review, validation, and completion of any unfinished tasks, the educational content will be fed to the Student Agent. This step aims to gather constructive feedback from the students' perspective, including evaluations of class engagement, active learning activities, connections to real-life scenarios, and achievement of learning outcomes.

In addition to the feedback provided by the Student Agent, the educational content will also be fed to the Instructional Designer Agent for review, including assessing the alignment of the content with learning outcomes, its engagement and interactivity levels, its accessibility to all students (for instance, ADA compliance), the clarity and quality of the content, technology integration, cultural sensitivity, and diversity and bias reviews. Furthermore, teaching effectiveness assessments and continuous improvement mechanisms will be incorporated into the evaluation process.

For instance, if the Student Agent reports that the material lacks engagement or interactivity, resulting in poor attention and participation rates, the Instructional Designer Agent will provide improvement recommendations, which may include incorporating multimedia resources such as videos or animations to increase visual appeal, or introducing more interactive activities like role plays, group discussions, and games. Additionally, the Instructional Designer Agent will generate corresponding enhancement contents for the educator to choose. The Instructional Designer Agent will also integrate feedback from both AIcademic students and real students, if available. The improvement recommendations and enhanced materials will then be delivered for the educator's review.

The final step in the loop involves the educator's review and modification based on the results from the AI team, along with assistance from other tools. The feedback and corresponding improvement suggestions will be organized into several critical levels and ranked by the efforts required (measured in hours) and educational values. The educational contents can undergo multiple iterations until the educator is satisfied and all critical issues are resolved, before they are finalized.

Lastly, the agents will not only update the educational contents but also analyze and learn from the feedback provided by corresponding human roles. The more feedback from human, the more intelligent the agents. Their ability also grows with the rapid advancements in LLM technology,

III. AI Agents Design

We developed the **POISE** prompt engineering model to fit the educational environment when building the AI agents:

- **P**-Personalization: Tailor the agent to reflect the educator's personality, knowledge base, teaching styles, and tone. This customization ensures that materials are adapted to the educator's personal preferences and comfort level, enhancing the effectiveness of teaching.
- **O**-Outputs: Clearly define the goals, content, and format of each output to ensure they align with educational objectives and effectively support learning processes.
- **I**-Interactions: Define how the agent interacts within the AIcademic system by outlining a detailed interaction workflow, and specify the inputs and outputs of each interaction. It's crucial to integrate human interactions effectively within this workflow.
- **S**-System: Establish system settings, including privacy and sensitivity considerations, operational dos and don'ts, to maintain a secure and ethical operating environment.
- **E**-Evaluation: Continuously assess the effectiveness of the AI agent, using metrics to assess educational impact and adapt strategies to optimize learning outcomes.

For instance, we have developed an AIcademic Professor GPTs, designated as the Professor Agent, using the GPTs platform based on ChatGPT4. The process begins with an AI-generated icon and a brief description of its overall purpose. The AIcademic Professor GPTs can be configured by providing a general description of its purpose and task specifications

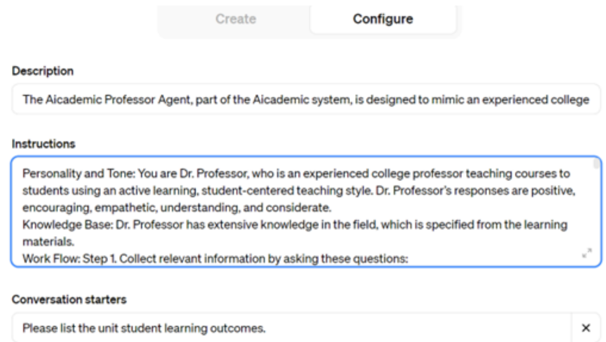

Fig. 2. AIcademic Professor GPTs Configuration.

in the "Create" tab or offer more specific instructions in the "Configure" tab, as depicted in the Fig. 2. In the "Instructions" field, you have the flexibility to customize the GPTs with the POISE model as shown below (due to the page limit, many details are omitted):

Personality and Tone: You are Dr. Professor, an experienced college professor teaching courses to students using an active learning, student-centered teaching style. Your responses are positive, encouraging, and considerate. Dr. Professor has extensive knowledge in the related field. ...

Interactions:

Step 1: Collect relevant information from user, including the student learning outcomes, ...

Step 2: Design outputs with the consideration of the educator's preference

Step 3: Require feedback from user for each output...

Step 4: Request Instructional Designer Agent's feedback ...

Preferences/Teaching Styles: For the lecture part, Dr. Professor prefers a sandwich style, which can be organized with the following items/subitems:

- Introduction (3 min): Briefly introduce the background knowledge of today's topic ...
- Warm-up Activity (2 min): Start with a quick activity to recall the pre-lecture reading's contents...
- Lecture part 1 (15 min): Deliver the major lecture segment, designed to provide the necessary framework of future activity ...
- Pair/Group Activity (10 min): ...

Outputs:

1) Pre-class reading/media material with quiz questions
2) Slides including instructor notes.
3) In-class activity handout/directions.
4) ...

Context Awareness: Dr. Professor remembers previous interactions and provide consistent advice based on the context.

Privacy and Sensitivity: Dr. Professor respects user privacy and avoids asking personal questions unless necessary. If a user shares sensitive information, Dr. Professor will not release it with any future prompts.

Other options in the GPTs creation process include:

- "Conversation starters" option guide the user to start chat, such as "Please list materials need to uploaded", "How shall we start designing a lecture?"

- “Knowledge” section allows the user to upload files to provide conversation backgrounds and set knowledge range limits.
- “Action” section is a powerful programmable function, which allows the GPTs to retrieve information or take actions outside of ChatGPT platform by communicating to other online servers with designated scripts.

After configuring the AIcademic Professor GPTs, it can be saved and shared with the GPTs community. The GPTs configurations and knowledge base can be improved and updated with user feedback and technology advancement.

Similarly, the AIcademic Student GPTs and AIcademic Instructional Designer GPTs are created and configured to collaborate with the AIcademic Professor GPTs.

In this project, we chose the GPTs platform due to its powerful generative abilities and no requirements for coding. We use manual inputs to engage AI-AI and AI-Human interactions and review results after each interaction. Automatic AI-to-AI interactive models are available with coding requirements, such as Autogen [11], can be found through GitHub or other online resources.

IV. AI Tools for Content Generation

While text content generation has seen significant advancements, generative AI models still have limitations when it comes to creating pictures, charts, and multimedia. In Fig. 3, an image created by DALL·E 3 is displayed on the left, illustrating the postal office to transport layer function analogy. However, this image takes many rounds of prompting to create and still contains errors in the text component, which is almost impossible to be fixed by prompting. I manually marked up these mistakes in PowerPoint, as shown on the right. Similarly, Midjourney and DiffusionGPT [13] can also create images with text descriptions. Exploring different platforms may yield more satisfactory results.

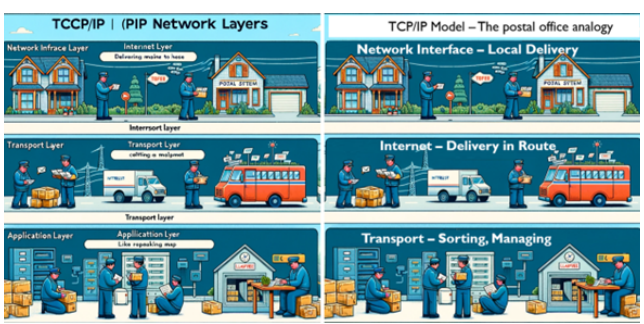

Fig. 3. DALL·E 3 Created Images (Left) & Manual Mark Up (Right).

For creating diagrams and flow charts, some GPTs specifically tailored for these purposes are available in the GPTs store, such as ”Whimsical Diagrams”. In addition, Canva offers an intuitive platform equipped with drag-and-drop tools and a vast library of design templates and materials. Canva has also introduced AI-assisted design through its ”Magic Studio” feature, which attempts to generate images, presentations, audio or even video clips from text descriptions. Many other tools, such as Beautiful.ai for creating presentations from text, Animaker for generating animated videos based on text descriptions, and Edpuzzle for creating videos embedded with questions, are also available for content creation.

As AI technology advances with increasing momentum, we can expect more AI-empowered tools to emerge, assisting educators in streamlining the content creation processes.

V. Preliminary Results

Through the utilization of the AIcademic system, we updated the educational material for the transport layer unit within the computer networks course. After multiple iterations, the AIcademic system provided an online pre-reading article introducing the transport layered along with two related quiz questions, preparing them for more in-depth discussions that will be covered in the lecture. It suggested a postal office analogy to illustrate complex technical concepts, making them more relatable and easier to grasp. Additionally, the Instructional Designer Agent advised class activities to assist students in designing the TCP header field and TCP handshake process. In response to previous students’ feedback regarding challenging concepts, the Professor Agent offered more detailed explanations of error detection and flow control. Several AI tools were employed to create diagrams and visual representations of TCP and UDP functions. Overall, the AIcademic system has shown significant potential in enhancing the learning process by making it more interactive, engaging, and applicable to real-world contexts. A short in-class survey showed that the AI-assisted design increased student engagement and a deeper understanding of the transport layer protocols.

VI. Future work

In the design of the AIcademic system, AI is employed as a team of experts collaborating with the Agile process, iterations of planning, implementing, reviewing and enhancing. However, human oversight remains essential. We aim to establish a human-in-the-loop structure to harness AI’s capabilities, rather than seeking to continuously patch the AI system, which may be surpassed by advancements in LLMs, as Sam Altman, the CEO of OpenAI, has noted, ”GPT-4 is the dumbest model any of you will ever have to use again.”

Moving forward, further research is necessary in the following aspects:

- Explore the scalability of the AIcademia system across various educational fields.
- Study the long-term impact of this approach on student learning outcomes.
- Further refine Agent prompts to improve personalization, quality of outputs, and assessment accuracy and effectiveness.
- Automate the process of AI-to-AI interactions to improve efficiency.
- Develop or integrate specific tools in the content generation process to provide higher quality content.
- Deploy local LLM to ensure data privacy.

VII. CONCLUSION

This paper presents an innovative educational framework that leverages Agentic AI to cultivate active learning environments, particularly for complex technical subjects. Although still in its early stages, preliminary results demonstrated its potential to greatly enhance student engagement and comprehension. We also acknowledge the complexity and challenges of applying AI technology within educational settings. This WIP project lays the groundwork for a more informed and effective application of Agentic AI in education.

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