# PockeTA: Virtual Teaching Assistant Platform with Course Context

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**Abstract.** PockeTA is an innovative pedagogical agent that utilizes AI technologies and is accessible both on campus and remotely. It can be used in a variety of situations, such as on PCs for studying and on mobile devices during field trips. The pedagogical agent, supported by a multi-agent system, is deeply integrated with a graph-based knowledge base, K-Cube, which is managed by teachers. Student data, such as questions, is collected, organized as learning analytics, and visualized for teachers to help them monitor students' progress and learning experiences. In this paper, we outline the framework of our system and share some promising early results. Positive feedback from early adopters demonstrates the potential of PockeTA in addressing the scalability challenges faced by human TAs. These challenges are particularly evident in many regions worldwide, where universities often struggle to improve the TA-to-student ratio due to resource constraints and growing student populations.

**Keywords:** virtual teaching assistant · e-learning · large-language models.

## 1 Introduction

Teaching assistants (TAs) play a pivotal role in the landscape of university education, serving as a critical bridge between faculty and students. TAs not only facilitate the dissemination of knowledge but also contribute to the overall academic development of students by providing supplementary instruction, personalized feedback, and mentorship. Their involvement is particularly significant in large classes, where individualized attention from the primary instructor is often limited. Through leading discussion sections, conducting laboratory sessions, and offering office hours, TAs enhance the learning experience and foster a more interactive and supportive educational environment.

Despite their importance, several challenges undermine the effectiveness of TAs in universities, particularly in the context of scalability and resource allocation. One of the most pressing issues is the insufficient ratio of TAs to students, which is a concern in many higher education systems worldwide. These challenges are often exacerbated by the increasing scale of higher education institutions and the growing demand for quality education. As a result, students in many regions may not receive timely feedback or sufficient guidance, which can negatively impact their academic performance and overall university experience. Rapidly rising student enrollments, coupled with constrained institutional resources, have created scenarios where a single TA may be responsible for supporting dozens, or even hundreds, of students. This imbalance significantly hampers the ability of TAs to provide meaningful, individualized support, thereby diminishing the quality of education on a global scale.

Fortunately, the advent of large language models (LLMs) and the progress on multi-agent architectures provide us with various paradigm-shifting tools to address this issue. Utilizing LLMs for e-learning is a current hot topic in education and Human-Computer Interaction (HCI) research. They mostly focus on specific tasks, such as writing assistance, code teaching [16,28,32,8], language learning [18,6], physical activity coaching [17] and integration with current pedagogy [27]. As LLMs can display human-like intelligence, it is a natural next step to consider them as the thinking module for virtual TAs as well. The underlying idea is not new. However, there seems to be a lack of effort in actually realizing it. Further, recent works seem to focus on text-based communication. On the other hand, previous studies have demonstrated that personifying an avatar can help establish social presence with users, thereby enhancing Human-AI trust and learning engagement, which in turn leads to improved learning outcomes [31,15]. There is a lack of virtual TA work that considers this point as well.

To this end, PockeTA has been developed as an ubiquitously accessible virtual teaching assistant, accessible across a university campus. The system is designed to be available across multiple platforms, including personal computers and mobile devices(Fig. 1). The user interface draws inspiration from remote meeting software (e.g., Zoom). Specifically, the PC and mobile interfaces emulate conventional remote meeting environments, wherein students can visually interact with the virtual TA avatar and engage in real-time dialogue. As the interface is similar to how students interact with a human TA remotely, it is easy to learn and intuitive to use. The platform supports document sharing, enabling PockeTA to review and provide commentary. This innovative approach fosters a sense of presence and interactivity, allowing students to engage with the virtual agent in a manner analogous to interactions with human instructors.

At the core of PockeTA's functionality is its integration with a graph-based knowledge base named K-Cube [21,29], which systematically connects course content and instructional materials. This architecture empowers the virtual assistant to deliver contextually relevant support and actively engage students in alignment with their curricular requirements. Furthermore, data generated from student interactions with PockeTA are systematically uploaded and visualized

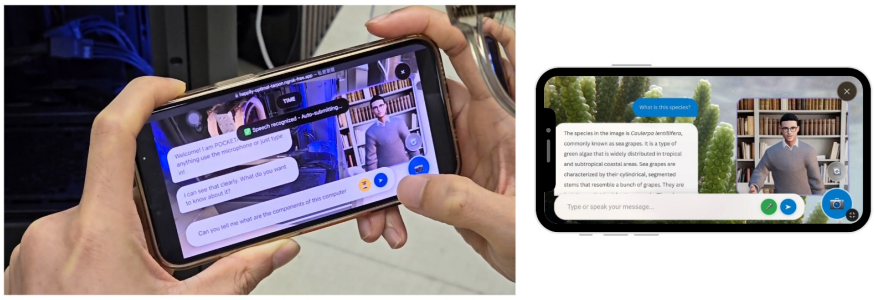

**Fig. 1.** Students can access PockeTA via mobile devices anytime, anywhere.

for instructors, providing a novel mechanism for educators to monitor, analyze, and respond to students' learning experiences. This dual focus on student support and instructional feedback positions PockeTA as a transformative tool in the landscape of university education.

## 2 Related Work

There are discussions on the application and benefit of virtual teaching assistants (vTAs). Early vTAs, such as Jill Watson, developed at Georgia Institute of Technology [30,11], demonstrated the feasibility of using AI-driven agents to answer student queries in online forums with high accuracy, thereby addressing scalability challenges in Massive Open Online Courses (MOOCs). Subsequent developments have focused on increasing personalization, as seen in architectures that incorporate student modeling and context-aware responses, enabling vTAs to recommend tailored learning materials and cluster students based on interaction patterns [7]. A vTA on WhatsApp, called KNUSTbot [9], has been shown, via empirical studies, that such a form of vTA can significantly improve academic performance and student engagement, particularly by providing immediate feedback and support outside regular office hours. There was a survey focusing on China, which presents a discussion that further highlights vTAs' potential to reduce teacher burden and improve access to educational resources, aside from underscoring the importance of cultural adaptation and ethical considerations [4]. More recent research has explored the integration of text-based generative AI models, specifically ChatGPT, which offer enhanced content creation and information retrieval capabilities, but also raise concerns regarding bias, privacy, and the depth of interaction. Despite these challenges, the literature consistently identifies vTAs as valuable tools for personalization, scalability, and accessibility in education, while calling for further research into their long-term impact, cross-cultural applicability, and ethical deployment [1]. However, previous works have yet to present a discussion on the system, interface, and the

personification of the vTA. We believe that our work is one of the pioneering efforts toward this endeavor.

The integration of LLMs into e-learning platforms marks a significant technological leap, fundamentally reshaping pedagogical strategies by creating more personalized, interactive, and efficient learning environments with the goal of approximating a 1:1 teacher-to-student ratio [24]. A primary application is the development of sophisticated virtual tutors that offer on-demand, individualized assistance; for instance, AI tools in Harvard's CS50 course were designed to guide students toward solutions, making them feel as if they had a "personal tutor", while the Iris chatbot uses subtle hints to foster independent problem-solving [5]. Empirical studies, such as a semester-long trial with the "CodeTutor" assistant, have validated this approach by showing significant improvements in student scores, although they also highlight student concerns that such tools may not sufficiently develop critical thinking skills [22]. This transformative potential is particularly evident in computer science education, where LLMs assist with code generation, debugging, and algorithmic explanation, with platforms for "prompt programming" and AI-assisted pair programming demonstrating enhanced student performance [3,25,23]. However, this is counterbalanced by the significant risk of over-reliance, where students can become trapped in a "vicious cycle" of submitting incorrect AI-generated code without developing a fundamental understanding, necessitating a pedagogical shift towards teaching verification and security for AI-generated artifacts [26,10,19]. Beyond direct student support, LLMs also empower educators by automating the creation of learning materials, such as generating initial drafts of worked examples in Java or drafting responses for TAs in class forums, thereby freeing up instructor time for more complex pedagogical tasks [12,20,13]. This highlights a critical gap that this paper addresses: the lack of a holistic, personified vTA that is deeply integrated with specific course contexts. Many existing systems face challenges with academic integrity, the potential for social erosion, and a growing digital divide [2,14]. PockeTA is designed to fill this gap by moving beyond simple Q&A to offer a comprehensive platform that combines a personified agent with K-Cube for true course-awareness, multi-modal interaction, and integrated learning analytics for instructors, thereby addressing the need for a more robust and contextually-grounded vTA as called for by the research community.

## 3 Features of PockeTA

In this section, we present the features of PockeTA, and highlight the difference between PockeTA and typical LLM-based e-learning systems.

**Q&A Assistant:** Naturally, one of the most common uses of PockeTA is to use it as a Q&A assistant to learn from (Fig. 2). It serves as an advanced query resolution system capable of delivering immediate responses to academic inquiries. Users submit questions via text input, and the AI leverages a connected knowledge base, course-specific materials, and general academic resources to generate explanations. The system supports conversational follow-up, enabling iter-

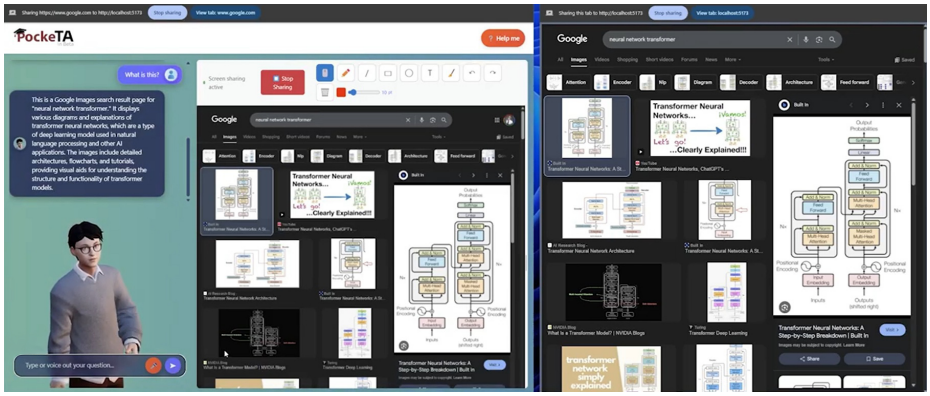


**Fig. 2.** PockeTA can answer academic questions in lieu of human TAs.

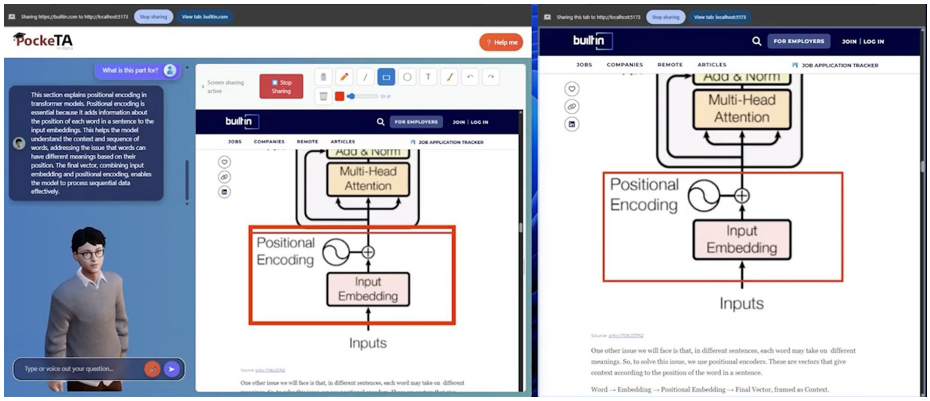


**Fig. 3.** Students can use the interactive drawing tools to express a question or bring PockeTA's attention to the annotated part(s).

ative clarification and deeper conceptual discussion. Questions asked by students will also be recorded for learning analytics.

**Interactive Drawing:** PockeTA incorporates a visual collaboration tool that enables users to sketch ideas on a digital canvas, thereby facilitating non-textual input and interaction. The canvas offers intuitive drawing tools, including freehand sketching, circling and annotation. Upon submission, the AI interprets the drawing—utilizing image recognition to provide relevant explanations. This feature is particularly advantageous for annotating non-textual content.

**Course Integration:** To ensure contextual relevance, PockeTA is embedded within academic curricula through direct integration with course-specific resources. Upon configuration—typically via the upload or linkage of syllabi, lecture slides, textbooks, or learning management systems—the AI retrieves these contents or information (via retrieval-augmented generation (RAG)) in inter-

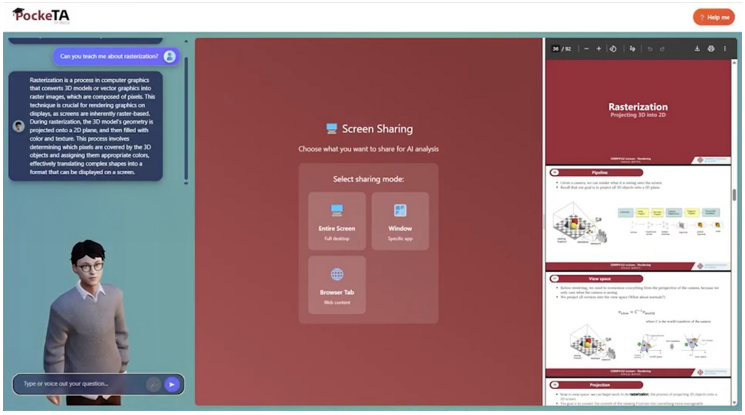


**Fig. 4.** PockeTA is course-aware. If relevant teaching materials (e.g., lecture slides) are available, PockeTA can present them to the student.

active time during user interactions. This alignment with curricular materials minimizes misinformation and enhances the applicability of responses. The system accommodates various file formats, which can support the management of multiple courses. It also includes usage tracking, which can later be used to understand the popularity of a particular teaching material.

**Academic Advising:** PockeTA offers a personalized academic advising module, providing tailored recommendations to guide students' educational trajectories. By analyzing user-provided data—such as academic goals, performance metrics, and assessment results. The AI can work with the student to design individualized study plans, provide course selection advice, and offer skill development suggestions.

**Learning in the Field:** PockeTA has a mobile version that supports off-campus, on-the-go learning that can benefit field-based learning (Fig. 5). The platform offers offline functionality with data synchronization upon reconnection and incorporates location-aware features, such as contextualizing queries based on the physical environment of the user. This capability is particularly valuable for disciplines that involve fieldwork, such as environmental or construction.

**Visualizing Learning Experience:** It is important for the teachers to understand the learning experience of their students. By connecting to K-Cube, PockeTA can provide learning analytics and enable visualization on students' learning trajectories through data-driven insights. The system aggregates interaction data—such as question frequency and employs expressive analytics to generate visual representations (e.g., charts, heatmaps, timelines) of knowledge gaps, strengths, and progress trends.

**K-Cube Connected Knowledge Base:** Underlying PockeTA's functionalities is K-Cube, a graph-based knowledge base (Fig. 6) that describes the content of a course and interconnects it with teaching material. Teachers will be editing the graph to change the content of their course; this will, in turn, change the

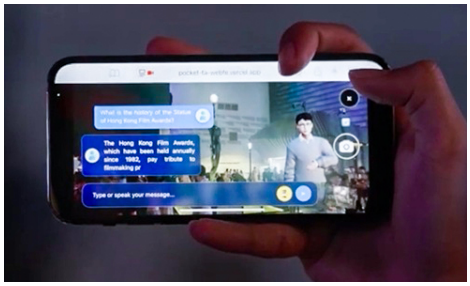

**Fig. 5.** The mobile version of PockeTA can be used to support field-based learning.

course context of PockeTA and change how it delivers content and interacts with the students.

**Fig. 6.** PockeTA is linked with K-Cube, a graph-based knowledge base for context.

**Comparisons with other LLM-based E-learning solutions:** Of course, it is possible to use a typical LLM-based (e.g. ChatGPT) interface or systems to engage in Q&A activities or text-based mini-lecture. However, we believe this would ignore several deficiencies in directly applying LLMs to an e-learning system. In Table 1, we highlight the benefits and differences of PockeTA compared to other LLM-based systems.

## 4 System Design

PockeTA's system is fundamentally driven by a sophisticated multi-agent framework responsible for orchestrating the system's intelligence, adaptability, and interactive behaviors (Fig. 7). At the heart of PockeTA lies a graph-based knowledge base, which serves as the central repository for course content, instructional materials, and domain-specific information. This graph database is structured to model the hierarchical and relational organization of each course, enabling not

**Table 1.** Comparison between PockeTA and general LLM-based systems.

| | **LLMs (e.g. ChatGPT)** | **PockeTA** |
|---|---|---|
| Answer to General Knowledge Questions | ✓ | ✓ |
| Answer to Course-specific/aware Questions | × | ✓ |
| Avatar for engagement | × | ✓ [15] |
| Invocation of Trust and Learning Confidence | × | ✓ [31] |
| Academic advising | × | ✓ |
| Course Content Linkage | × | ✓ |
| Learning Analytics Visualization | × | ✓ |
| Teacher Controllability | ✓ (Partially, requires the teacher to manipulate the prompt which requires technical knowledge) | ✓ (Manipulate via a knowledge graph that defines the teaching context) |

only efficient retrieval of relevant educational resources but also facilitating advanced learning analytics. For instance, the system can track and analyze student engagement by monitoring the frequency and distribution of questions posed on particular topics, thereby providing valuable insights into learning patterns and areas requiring further instructional support.

The multi-agent architecture comprises a collection of specialized agents, each designed to handle distinct aspects of student interaction, such as question answering, academic advising, and the delivery of ad hoc mini-lectures. These agents operate in concert, leveraging their individual expertise to deliver a seamless and contextually appropriate learning experience across various PockeTA frontends, including desktop, mobile, and immersive environments. When a student initiates a query—whether seeking clarification on a complex concept, requesting personalized academic guidance, or engaging in interactive mini-lectures—the system employs RAG to dynamically fetch the most pertinent context, content, and information from the underlying databases. RAG acts as an intelligent intermediary, synthesizing data from the graph-based knowledge base, course material database, and study information repositories to ensure that responses are both accurate and tailored to the student's immediate needs.

This architecture is further enhanced by an interaction database, which continuously updates with new data generated from student-agent exchanges. These interactions are visualized and made accessible through K-Cube, a dedicated interface for instructors and administrators. The portal empowers educators to exert granular control over PockeTA's behavior, edit and curate course contexts, and access a suite of learning analytics tools. Through these analytics, teachers can identify commonly asked questions, monitor student progress, and adapt instructional strategies to better address emerging learning challenges.

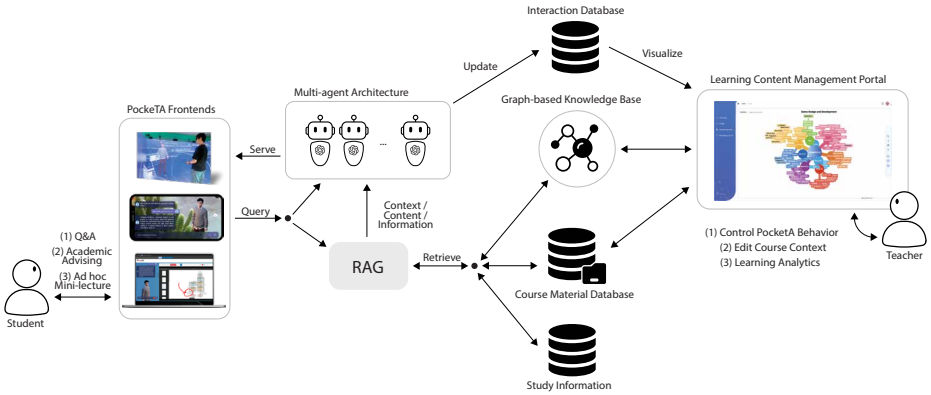


**Fig. 7.** PockeTA system architecture

## 5 Use Case Narrative

To illustrate the practical applications and potential impact of PockeTA, two representative use case scenarios are presented: the student perspective and the teacher perspective.

**Student Perspective:** Consider the case of a university student who engages in self-directed study during late-night hours. In such circumstances, access to human teaching assistants (TAs) is typically constrained due to limited availability outside of standard working hours. PockeTA, as an AI-powered vTA, addresses this gap by providing on-demand academic support. While it does not fully replicate the nuanced expertise of human instructors, PockeTA is designed to facilitate natural, dialogic interactions that emulate the back-and-forth communication recognized as effective in constructivist learning paradigms. Furthermore, the virtual agent possesses the capacity for unlimited patience, enabling extended learning sessions tailored to the student's pace and needs. This persistent availability and adaptability can foster a more supportive and responsive learning environment, particularly for students who require additional time or repeated explanations to master complex concepts.

**Teacher Perspective:** From the instructor's standpoint, PockeTA offers valuable insights into student learning behaviors and areas of difficulty. Following each student interaction, the system generates a session report that is transmitted to a backend analytics platform. This report includes metadata such as the topics discussed and the specific questions posed by students. The aggregated data are visualized atop a knowledge graph, allowing instructors to identify frequently asked questions and common areas of confusion. Such data-driven feedback enables educators to make informed adjustments to their teaching strategies, curricular content, or supplementary materials, thereby enhancing the overall effectiveness of instruction. By integrating PockeTA into the teaching workflow, universities can leverage real-time learning analytics to support continuous pedagogical improvement.

## 6 User Study

Our system has been released for beta testing. In order to get insight as to how learners may interact with our system. We have recruited 16 volunteer users to test our system and conduct an online structured interview. To analyze the data, we conducted thematic analysis with coding to extract useful qualitative data artefact. The thematic analysis of the structured interview data revealed a range of user perspectives, expectations, and concerns regarding the development and deployment of PockeTA. The analysis identified six major themes: (1) Personalized and Contextual Learning Assistance, (2) Emotional and Social Dimensions, (3) Technical Reliability and Safety Concern, (4) Requested Features and (5) Requested Use Cases. Each theme is illustrated below with representative participant quotes.

### 6.1 Personalized and Contextual Learning Assistance

Analysis of student feedback reveals that PockeTA's most valued attribute is its ability to deliver highly personalized, context-aware support that is closely integrated with course materials and responsive to individual learning needs. Participants consistently described the system as both innovative and practical, with one student noting: *"My first thought on PockeTA is that it's a very useful and forward-thinking idea. Having a personal vTA that's connected to my course material could really improve how I learn, ask questions, and get help whenever I need it."*

The platform design was seen as encouraging active engagement and curiosity. As one user shared: *"It looks very interesting, and the digital teacher encourages me to ask some interesting questions."*

The availability and personalization of support were also highlighted as key strengths. One participant remarked: *"I think developing a personalised, 24/7 TA is a great idea," while another praised the immediacy of the system's responses: "Its ability to read from the screen in real time is great."*

Several students expressed that PockeTA exceeded their expectations, with one stating: *"That's amazing and beyond my expectations. I truly anticipate its further development and deployment."*

The convenience and creativity of the platform's design were also frequently mentioned. As one respondent put it: *"It is a very convenient and creative design. If the effect is significant, it will be very helpful for students to learn."*

Importantly, students appreciated PockeTA's ability to provide course-specific explanations and practical examples. One user explained: *"It can retrieve the slides on the subject of the course I enrolled in, explaining the idea in a way that includes analogical real-life examples and application examples, allowing me to grasp the concept quickly, then start digging down step by step."*

One participant appreciated the assistant's real-time capabilities: *"Its ability to read from the screen in real time is great."*

Finally, the system's capacity to deliver immediate, tailored academic support was emphasized by another participant: *"PockeTA can help me study by*

*giving quick, accurate answers when I'm stuck, explaining difficult concepts in a way that matches my course material, helping me review with summaries or practice questions, and making it easier to stay organized and focused throughout the semester."*

Collectively, these responses illustrate that students perceive PockeTA as a transformative tool that not only provides timely academic assistance but also can adapt to their unique learning contexts, thereby having strong potential to enhance both engagement and learning outcomes.

### 6.2 Emotional and Social Dimensions

While most feedback focused on functional aspects, several participants highlighted the emotional and social support that PockeTA could provide. The sense of having a companion or support system during study was valued by some users.

One participant described the assistant as a supportive presence: *"I like the idea that a man is standing aside. It feels like someone is accompanying the study."*

Another suggested that the assistant could offer more than just academic help: *"I suggest that the TA offer more emotional support."*

The ability to escalate questions to a real teaching assistant was also seen as a way to provide reassurance and human connection: *"Provide the option to escalate questions to a real TA when needed."*

### 6.3 Technical Reliability and Safety Concern

Participants raised several technical concerns, particularly regarding bugs, interface issues, and privacy. These concerns underscore the importance of robust, user-friendly, and secure design.

Interface usability was also a concern: *"I think the selection box cannot effectively select the content I want, especially since it cannot adapt to different screens, which will cause relatively serious deviations. I hope it can be improved."*

Privacy and control over the assistant's actions were highlighted: *"But I'm not feel safe when it asked me to share the screen." "I can't really control the TA speaks out the answer or not. Sometimes I typed the question wrongly, the TA speaks the answers out, but I cannot stop him, which I still need to wait for him to finish his sentence and then I can finally get my true answer...."*

### 6.4 Requested Features

Beyond Q&A, participants envisioned a suite of advanced features to support their learning. Summarization, quiz generation, and multimedia explanations were among the most frequently requested enhancements.

For example, one participant described the value of content summarization and practice questions: *"Summarizing lecture slides or notes to help me revise faster before exams and generating practice questions or mini-quizzes based on recent topics I've studied."*

The potential for multimedia support was also highlighted: *"If it can create some images or animations to match with the answers, it will help me to understand the answers better."*

Participants also wanted the assistant to help them monitor their learning journey: *"Perhaps it can help to summarize the questions that I asked? And show my learning progress?"*

The desire for features that facilitate active learning and self-assessment was echoed by another respondent: *"It can give me a short quiz to verify my knowledge."*

Participants also mentioned the importance of being able to input information in various ways, such as through voice or audio: *"I think it would be beneficial to add functions like audio recognition and analysis. If I have any doubts about a certain statement taught in class, I can obtain the knowledge imparted by the professor by inputting and analyzing this audio."*

Participants also expressed interest in the assistant adapting to their learning progress and needs: *"In the future, I'd like PockeTA to offer context-aware answers based on the course I'm studying, track my learning progress to highlight weak areas, generate practice quizzes or flashcards automatically, help me plan my study time with reminders, provide the option to escalate questions to a real TA when needed, and support multimedia content like diagrams or videos to explain complex topics more clearly."*

### 6.5 Requested Use Cases

Finally, participants envisioned a wide range of potential use cases for PockeTA, extending beyond individual study to classroom integration, research, teaching, and even programming support.

For classroom use, one participant suggested: *"I think this app can be extended for use in the classroom. When students share the teacher's live broadcast on this app, they can quickly solve the problems they encounter in class."*

Some tutors saw value in research and teaching: *"Give me some ideas on the concepts, helping me to do my research or perhaps helping me teaching."*

The potential for programming and debugging support was also noted: *"Not just a simple chatting, and help to understanding some concepts. But also help me in other learning process, like debugging, programming, and creating . . . "*

### 6.6 Discussion

Students consistently describe PockeTA as a "forward-thinking idea" and a "very convenient and creative design", highlighting its role as a personalized, always-available assistant that is closely tied to their academic materials. The ability to retrieve and explain course slides, provide analogies and real-life examples, and offer quick clarifications and summaries is seen as transformative for their learning experience. The feedback also underscores the importance of usability, with students praising features like real-time screen reading and the intuitive design. The motivational aspect of having a digital teacher that encourages inquiry

and supports active learning is also evident, suggesting that PockeTA can positively influence student engagement and confidence. While technical reliability and safety remain important considerations, the positive responses indicate that, when these aspects are well-managed, PockeTA has the potential to significantly enhance the academic experience. The assistant's versatility in supporting different types of content and learning scenarios further broadens its appeal and impact. In summary, the expanded evidence base confirms and deepens the initial thematic analysis: students value PockeTA for its personalized, context-aware support, advanced learning features, ease of use, and motivational presence. These qualities position PockeTA as a promising tool for improving learning outcomes and fostering a more engaging, supportive educational environment.

## 7 Conclusion

In this paper, we have demonstrated that an AI-powered virtual teaching assistant system like PockeTA has strong potential to address scalability and the lack of learning personalization in higher education. By integrating course-specific knowledge, real-time analytics, and interactive features, PockeTA provides students with immediate, tailored support and empowers educators with insights into students' learning experience. User feedback highlights its effectiveness in enhancing learning engagement, organization, and confidence.

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