SEEM 3680 Project Report

Technology, Consulting, and Analytics in Practice

Agor.ai

Conversational Retrieval Augmented Generation AI Teaching Assistant

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Contents

1 Problem Statement

Education is a fundamental right, yet students worldwide are facing barriers to effective learning. Post-pandemic, educational outcomes have declined significantly globally, with the OECD's Programme for International Student Assessment (PISA) finding a decrease of 14 percent of a standard deviation in student scores - a loss equal to 7 months of learning (PISA, 2022).

While this demonstrates the disruption of COVID, this can also be partially attributed to the immense pressure on teachers and insufficient support systems. In 2023, a survey conducted by the Hong Kong Federation of Education Workers revealed that 90% of teachers experienced high levels of stress, with more than half working over 60 hours per week. This workload leaves teachers unable to provide personalized attention to students in increasingly large classrooms, resulting in hesitancy among students to seek help and a lack of tailored academic support. As such, the math and reading skills of high school students in Hong Kong has fallen (Tse, 2023).

This issue reflects a global trend of overwhelmed educators, rising student-to-teacher ratios, and reduced one-on-one interactions. As the demands on teachers increase, the gap between students needing support and the ability of educators to deliver it continues to widen. Without innovative solutions, the quality of education and its ability to meet the diverse needs of students will continue to deteriorate, exacerbating inequities and hindering long-term societal progress.

2 Motivation

As aforementioned, education is the backbone of societal progress, but the current state of overwhelmed teachers and unmet student needs jeopardizes this foundation. Large class sizes and excessive teacher workloads result in students hesitating to ask for help, leading to knowledge gaps that compound over time. This issue is particularly dire in a post-COVID world where educational disparities have widened to periods of at-home learning, and global test scores are declining at an unprecedented rate.

Teacher's ability to foster meaningful learning experiences is compromised by time constraints and insufficient resources. Without significant intervention, these challenges will not only limit the academic potential of students but also perpetuate cycles of inequality and underachievement. By addressing the disconnect between teachers' capacity and understanding of their students' needs, we can create a more effective and resilient educational system that benefits all stakeholders.

This urgency to act stems from the long-term societal and economic costs of an inadequately educated population, including reduced innovation, limited career opportunities, and diminished quality of life. It is imperative to reimagine how education is delivered and supported to ensure every student can thrive in a rapidly evolving world.

To address this issue, we are proposing a solution that can bridge this gap of understanding between educators and their students. A retrieval augmented generation chatbot would be able to answer student's

questions more accurately than existing commercial tools while combining with an educator dashboard would also ensure teachers are informed on areas their students may be struggling with.

3 Approach

In order to understand and address the pain points of the problem, let us envision two user groups.

3.1 Personas

Juan
Age: 15
Occupation: High School Student
- Wants to enjoy high school life
- Worries about falling behind with school work
- Not comfortable in asking the teacher questions in class

Key Needs:

- 24/7 support so he can get questions answered even after school hours
- Wishes it was easier to ask for help than asking in front of the whole class, and the teacher is not normally free before or after class.

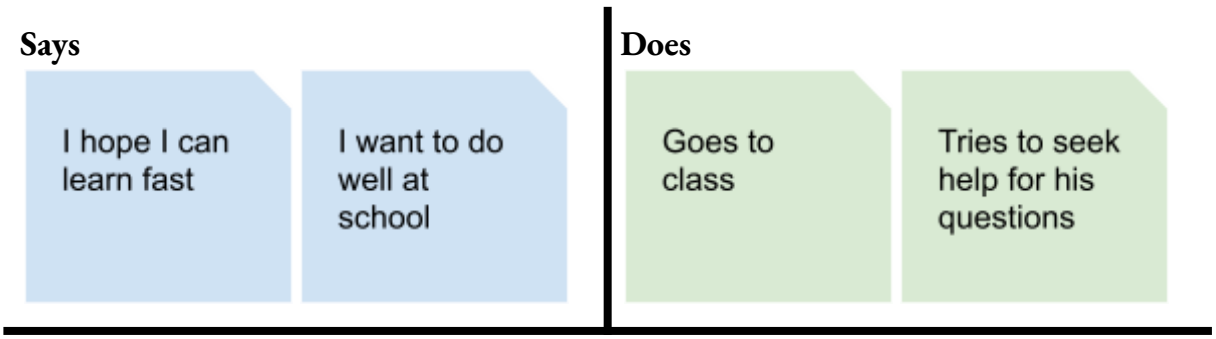
Ellen
Age: 35
Occupation: High School Teacher
- Wants to teach students effectively
- Worries that she isn't able to support each student individually

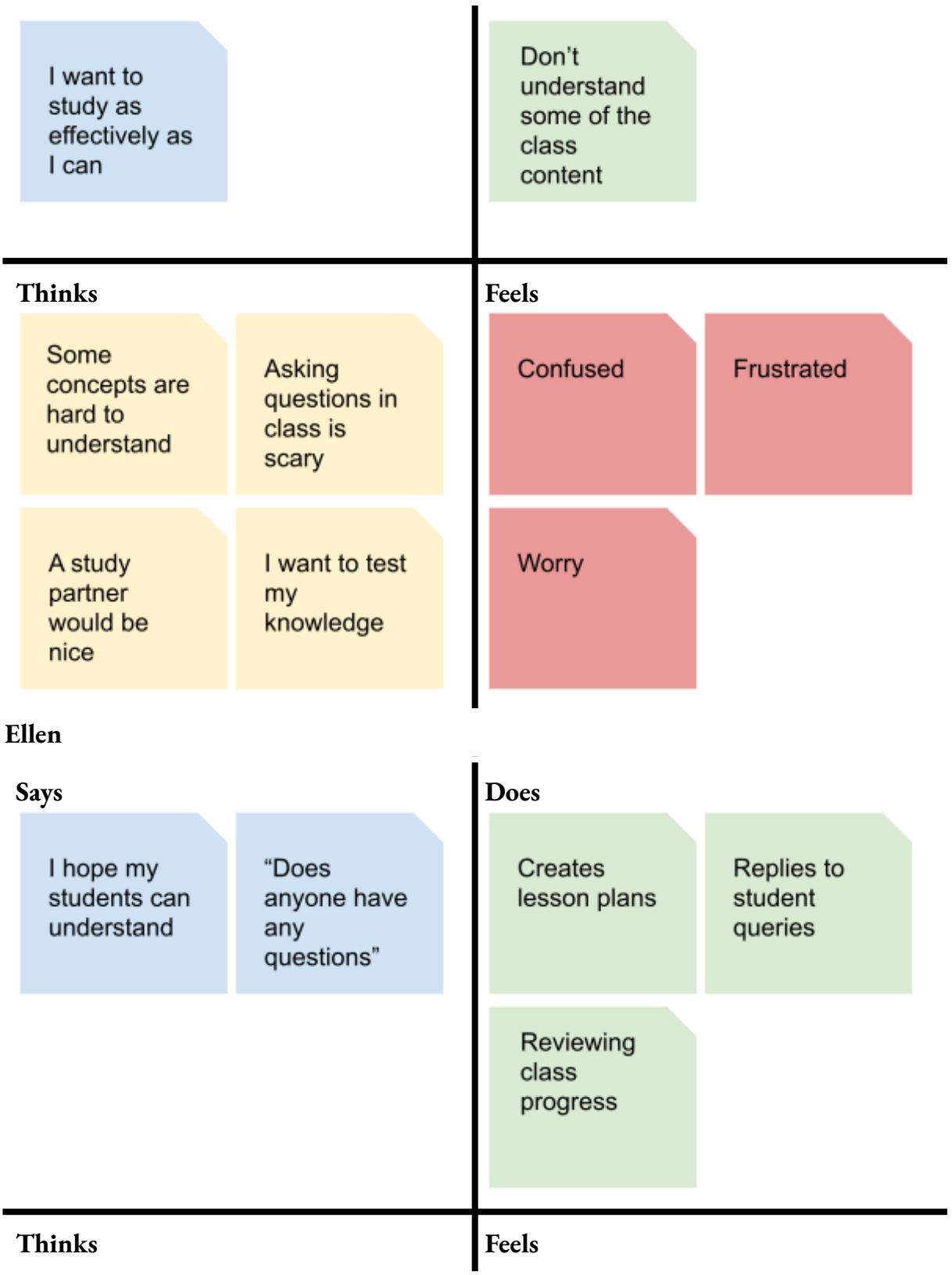
Key Needs:

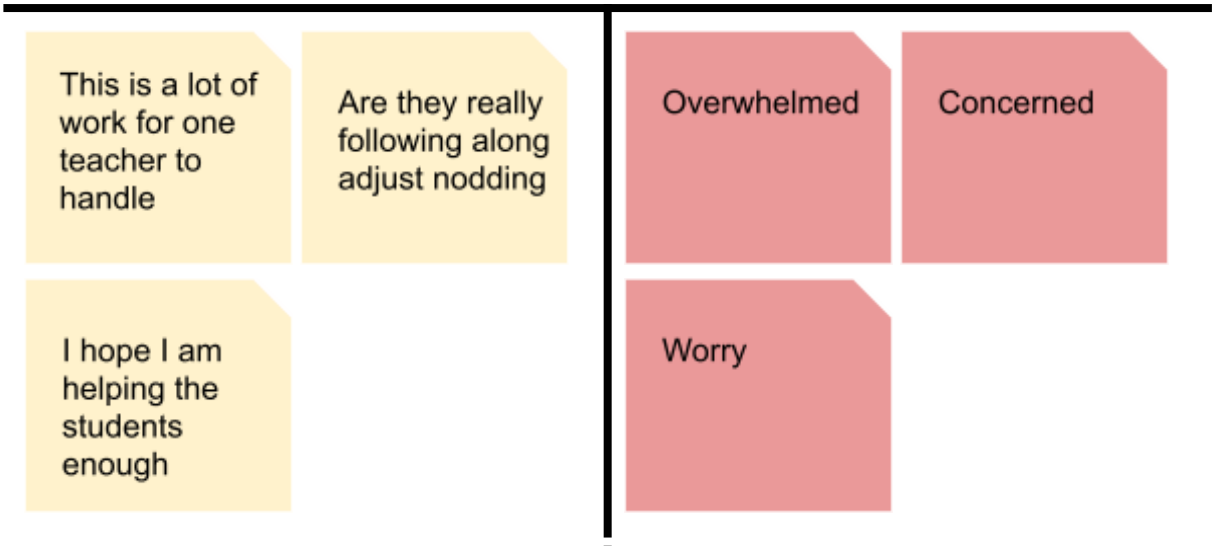
- Needs support on answering questions of her large class
- Wants to understand the progress and the needs of each individual student

3.2 Empathy map

Juan




I want to study as effectively as I can
Don't understand some of the class content
Thinks
Some concepts are hard to understand
Asking questions in class is scary
A study partner would be nice
I want to test my knowledge
Feels
Confused
Frustrated
Worry
Ellen
Says
I hope my students can understand
"Does anyone have any questions"
Does
Creates lesson plans
Replies to student queries
Reviewing class progress
Thinks
Feels



3.3 As Is Scenario Maps

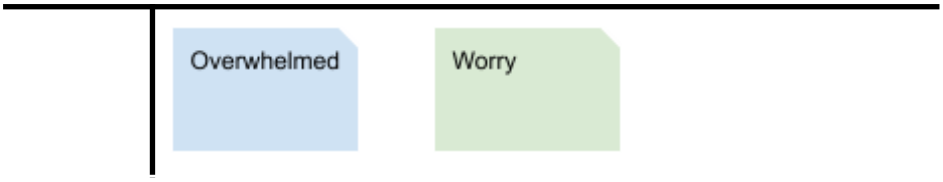
Juan

	Prepare	During	After
Doing	Check content in textbook Do readings	Limited time for teachers to address every question Taking notes Hard to focus in class	Pays for a tutor to explain concepts Asks friends for help Not enough time to ask hard questions to the teacher
Thinking	So many hard concepts Hard to imagine in practical use Why is this topic even important?	Should I even pay attention if I can't understand Still cannot understand some topics	Can I do well in the test? Can I cover all the material?

		Rather do something else thats fun	Googling this concept is boring and not helpful
Feeling	Stress	Confused	Anxiety
	Procrastinate	Worry	Depressed

Ellen

	Prepare	During	After
Doing	Making lesson plans	Teaching content	Review taught content
	Reviewing class progress	Answering questions	Follow up on student queries
			Start preparing for the next lesssion
Thinking	Such much menial work	Are the students engaged?	Did the students understand the content?
	Is this relevant to the students?	Not enough time to answer all students	Did I cover all the class content well?
	Why is this topic even important?	Hope students are comfortable to ask questions	
Feeling	Stress	Uneasy	Anxiety



3.4 Needs Statement

Juan needs a way to be able to get his questions answered promptly and accurately, in a non-judgmental and intellectually engaging way.

Ellen needs a way to understand and address the individual educational needs of her students as efficiently and quickly as possible so she can also balance all her other duties as a teacher.

3.5 Ideation

After exploring the personas of our audience, we decided that we need a solution that can both support a student's learning and alleviate the stress on teachers. In doing so, our product would have to address a student's concerns in a timely fashion, and allow teachers to complete their own curriculum and lesson planning tasks more effectively.

We would also have to address the growing sense of alienation students feel through the rise of automated responses and text based assistants that favour an older user base instead of younger students. Furthermore, we need to address the difficulty that teachers are facing to understand the needs of their class, especially as class sizes get larger and as teachers acquire more responsibilities. To allow teachers to better grasp the needs of their class, we will introduce a teacher dashboard that aggregates the questions that their student's are asking the chatbot and report trends in concepts or topics that students are struggling with, along with students who may be falling behind. This way, teachers can catch onto any issues early on as students are often hesitant to seek help.

Our solution of an AI education assistant with a realistic visage and teacher dashboard combines existing products into a combination that does not yet exist to most effectively solve our problem.

4 Implementation and Experimentation

4.1 Existing Competitors

Khanmigo

Learners often respond better to interactive and multimedia elements, which capture their attention and maintain engagement (Neo et al., 2012). As Khanmigo is text-based, it may be less engaging for students, leading to lower retention and interest over time. Students have also reported finding the large chunks of text produced by Khanmingo overwhelming and hard to understand, especially for younger age groups (Goldstein, 2023). As it has been found that students are able to form stronger connections with voice and visual animations (Ward et al., 2013), Khanmigo's lack of such functionalities can feel impersonal, which may impact its effectiveness in creating a positive learning environment for young learners.

Users can also only converse with Khanmigo through text as it cannot accept or produce visual input. That could be inconvenient for users as many students, especially in maths, science, and art, often work with visual materials, resulting in students unable to get feedback on their work, or having to type up their math workouts which is inconvenient. Furthermore, Khanmigo is unable to create diagrams which could impede learning in subjects such as science.

Khanmigo's also has limited tools that aid the educator's side, specially on helping them grasp the skill level of their class.

4.2 How Our Solution Is Better

As found in past studies, students report increased engagement and interest in the subject through natural conversation and spoken question and answer processes in virtual environments, with academic results similar to human tutors (Falloon, 2009). Our solution leverages this approach to improve the AI chatbot model used in education today. Instead of an impersonal, typed conversation with the AI, students would be able to converse verbally with a teaching assistant that has a realistic avatar, similar to a human tutor on an online platform like zoom.

Furthermore, we leverage the transformative impact of personalised teaching with a principle that educational psychologist Benjamin Bloom termed as the 2 Sigma Problem. Bloom found that students tutored one-on-one using mastery learning techniques performed two standard deviations better—putting the average tutored student above 98% of students taught in traditional classroom settings, with almost all tutored students outperforming 80% of the classroom students (Bloom, 1984). By combining modern developments in technology to realise this enduring educational principle, we are able to aid the delivery of more effective education.

4.3 Technology Behind Our Solution

Our solution integrates several advanced technologies to create a highly interactive and supportive educational experience through a generative AI technology with a virtual avatar.

4.3.1 Retrieval-Augmented Generation (RAG)

Unlike traditional large language models (LLMs) that generate responses solely based on pre-trained knowledge, RAG integrates a retrieval mechanism that sources real-time information from an external database or knowledge base. This structure enhances the chatbot's accuracy, relevance, and scalability in educational contexts where accurate and up-to-date responses are crucial.

This technology will greatly increase the accuracy of the responses that our technology provides. By grounding generative outputs with retrieved educational materials, RAG ensures that responses align with verified knowledge, minimising the "hallucination" of incorrect facts. Educators can continuously update the database with new curriculum materials, allowing the technology to stay current without retraining the

entire model. The retrieval component can be fine-tuned to select content that matches each student's learning level and progression, enabling personalised educational support.

4.3.2 Speech Recognition and Text-to-Speech

Speech recognition and text-to-speech (TTS) are crucial for enabling voice interactions.

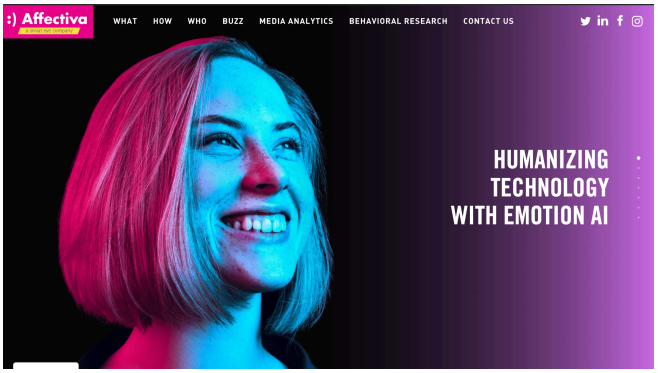
Systems such as Apple's Siri and Amazon's Alexa illustrate the utility of speech recognition and TTS technologies in delivering hands-free, voice-activated responses. Additionally, Google's Text-to-Speech API and Azure speech technologies powers a wide range of applications with natural-sounding verbal outputs, while language-learning tools like Duolingo utilise TTS for providing instant verbal feedback.

In our project, speech recognition will allow students to ask questions verbally, creating a hands-free and intuitive interaction experience. The TTS system will enable the avatar to respond with natural, human-like speech, making the learning process more immersive.

4.3.3 Computer Vision and Emotion Detection

Computer vision technology enables the avatar to observe and analyze students' facial expressions or body language, allowing it to detect emotional cues such as stress or confusion. Emotion detection relies on computer vision algorithms that interpret facial landmarks and tone, making the avatar capable of responding with empathy.

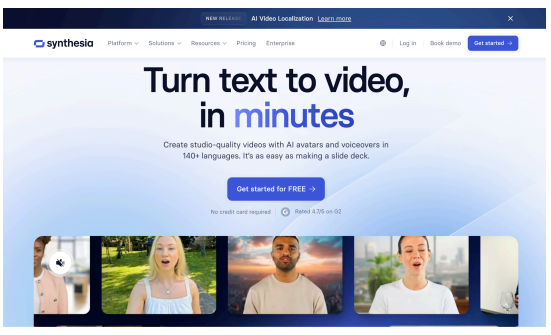
Companies like Affectiva specialise in emotion AI, providing systems that gauge user emotions based on facial expressions, which is valuable in fields like healthcare and customer service. Additionally, educational technology firms such as FutureSim Labs employ emotion AI to monitor students' reactions and adapt educational content in real-time to improve engagement.



Our technology's avatar will employ computer vision to observe student emotions, adapting responses based on visual cues.

4.3.4 Avatar Design and Animation

A visually engaging virtual avatar is essential for maintaining student interest and creating a humanised interaction experience. The avatar will be designed with realistic facial expressions, body language, and responsive animation to make conversations feel dynamic and immersive.



Platforms such as Synthesia and Replika utilise lifelike avatars to deliver content in a humanised way, helping users feel more connected to the system. In education, such avatars provide a sense of presence, creating a more interactive and enjoyable experience for students.

In our solution, a well-designed 3D avatar with expressive facial and body animations will serve as a "virtual teacher," responding to students with visual cues like nodding, smiling, or thoughtful expressions.

4.3.5 Custom Dashboard for Monitoring Student Engagement and Interaction

The dashboard will allow teachers to monitor student interactions with the technology, providing metrics on frequency and quality of engagement, as well as emotional feedback indicators. Tracking metrics such as session duration, number of queries, and topics discussed helps identify areas of interest and challenge. Teachers also have access to anonymized, aggregated emotional data, allowing them to see trends in student emotions (e.g., frustration, boredom) related to specific subjects or topics. Emotion-based learning analytics enhances teaching methods, as instructors can intervene when students consistently show negative emotions, thus reducing learning-related anxiety.

By integrating these technologies, our solution provides a comprehensive, adaptive, and emotionally supportive learning experience that leverages conversational AI, voice interactivity, emotion recognition, and visually engaging avatars.

4.3.6 Data Collection and Processing

The technology's effectiveness depends on the quality and scope of the educational content it can draw from. To build a solid foundation, we plan to incorporate data from sources such as the Standardised curriculum content and subject-specific educational databases.

Collecting content from K-12 and higher education curriculum standards (e.g., Common Core for the U.S., GCSE for the U.K.) ensures the technology provides academically accurate and relevant information across subjects.

Incorporating specialised databases, such as PubMed for science content, MathWorld for mathematics, and literature repositories, will enable the technology to provide in-depth answers across domains.

To train the emotion detection component, we require diverse datasets that accurately capture a range of human expressions and emotions, ensuring the avatar's responses are empathetic and supportive. Key datasets and methods include the Facial Emotion Recognition (FER) and Naturalistic Data Educational Settings Datasets. Datasets like FER2013, RAF-DB, and AffectNet contain labelled images of facial expressions across cultures and age groups, which helps in training the technology to detect a broad spectrum of emotional cues. Research shows that integrating FER datasets enhances accuracy, with studies reporting up to 75% accuracy in complex emotion detection models, which is crucial for an educational setting where emotional responsiveness supports student engagement . In addition, we plan to also incorporate data from educational settings, where students' emotional states can be observed during learning activities, enabling the system to capture more authentic emotional cues. By doing so, the system

could engage in more effective teaching such as providing encouragement or feedback in response to the student's emotions.

5 Business Analysis

5.1 Strategic Roadmap

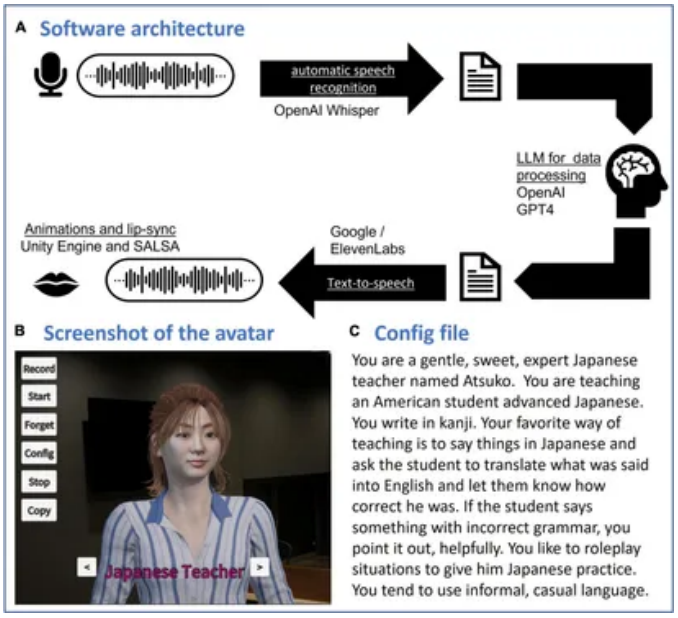
5.1.1 Design

The first stage is to design the user requirements. Our target audience are students of age 12-18 in content-heavy subjects such as history, economics, computing, or foreign language studies; our main goal is to create personal conversational partners that can cater to each individual. The focus on such subjects is to bring the most value into our product as much as possible; subjects which require a lot of content to be studied and memorised stand to benefit the most. For instance, instead of searching for an answer to a particular question by manually sifting through a thick textbook, the student can opt to ask Agor.ai for a brief explanation, and may inquire further should they wish to gain a better understanding. Quantitative-heavy subjects such as maths and sciences may be implemented in the future, however it is not our focus now.

In order to properly understand our users and to reach our goal of a personalised conversational partner, it is our belief that there is no better way to work with professionals with experience in teaching students. Throughout the designing process, it is absolutely necessary to consult with teachers, lecturers, or tutors in the industry who have firsthand experience in dealing with students in our target age group and academic subjects, therefore having an understanding of their needs.

5.1.2 Build

With specific user requirements in mind, the next logical step is to build an early prototype of Agor.ai. In this stage, implementing core functionalities is the priority, with focus on the overall user experience. Our goal is to implement only the main functionalities of the product: Retrieval Augmented Generation(RAG), speech recognition, text-to-speech, avatar design and animations, and the teacher dashboard system.



Software Architecture for GPTAvatar (Fink, 2024)

This phase will include developing realistic, responsive 3D avatars with expressive animations to enhance user engagement, training the language model on educational data, and building the teacher dashboard to provide data analytics and configuration options, enabling educators to monitor and adjust the chatbot's responses and understand where it exceeds or fail to meet standards. We will include API integration and connect components like speech recognition, text-to-speech, and emotion detection for smooth interaction with the avatar.

Building the software will also bring to light the technical constraints of our system and may lead to aligning the functionalities and user requirements to it. Multiple initial models will be developed for this purpose. Our testers will include internal teams and outside collaborators that have worked with us since the designing stage. Both the initial design and building phase should take roughly 3 - 4 months.

5.1.3 Pilot

An alpha version of Agor.ai will be implemented into small to medium-sized academic institutions such as schools and tuition centres in Hong Kong. The aim of this stage is to allow users, being students, to finally test the product. As we have a working demo of our product, we can convince smaller sized academic institutions for a partnership, starting with just one or a few academic subjects. Testing in a real environment is vital to allow collecting valuable user data. This will be a continuous cycle of monitoring, analyzing, and further refining our design. Furthermore, this will give insights into how students perceive Agor.ai across different ages and subjects of our choice, which the students themselves are the best judges of, not their teachers.

A comprehensive survey will be conducted as students and teachers use Agor.ai. User requirements are subject to change, and we will receive feedback into the core functionalities of our product. For students, we will focus on their overall experience in interacting with the avatar, and for teachers their experience in using the teacher dashboard system, how accurately the AI system gives answers to student inquiries, and whether or not Agor.ai overall has had a positive impact on student's learning experience. There is also tremendous value found if Agor.ai is able to be integrated seamlessly into the curriculum, either partially or fully, without disrupting other existing parts. In order for results to properly blossom, an extensive period of up to 1 year of continuous testing, monitoring and improving Agor.ai is necessary. If needed, this process may take longer before launching the product. If the launch is premature, and the user experience and quality of assistance subpar, students' willingness to use Agor.ai may be lackluster. We want to be very confident about our products' ability before launch, especially since what is at stake is a generation of students' learning experience.

5.1.4 Network

While Agor.ai is being tested in the field, building a network of relationships and staying up to date with recent technological advancements of AI is essential. One of the limitations of large language models today is that it may still give inaccurate or unfaithful answers from time to time. Staying up to date with state-of-the-art technology will potentially allow Agor.ai to improve its core functionalities before launch.

Improving the effectiveness of Agor.ai will also allow the creation of new relationships with other potential institutions, or stakeholders, that are interested. The pilot implementation is for this exact cause - to show that Agor.ai can be applied in a real setting and is continuously improving its performance; even if it is currently operating in a smaller-sized institution. This will open more opportunities to implement our product to a variety of environments where more users means more feedback for our team, which is essential. Creating potential future stakeholders will benefit us greatly before and after launch to attract bigger institutions.

In Hong Kong, there are many competitions and techathons held regularly every year, which is one of the opportunities to introduce others to Agor.ai. Similar to our previous presentation, we will first frame the problem about the current situation of education in Hong Kong, what is Agor.ai and what it is able to do, why it can solve the problem and communicate clearly the benefits it will bring to educators and students. In addition, we are also able to show that an alpha version has already been implemented in a real setting from the previous phase. Overall, this phase of the roadmap will start after the building stage and will continue until post-launch.

5.1.5 Launch

There are two metrics to reach before fully commercializing Agor.ai: the full integration of Agor.ai in 2 or more institutions and achieving an overall accuracy rate of more than 98%. The business model will be subscription-based with the target stakeholders being academic institutions ranging from small to large, similar to how Microsoft 365 currently offers their services in CUHK and many other schools.

The choice of having at least 2 institutions fully adopt Agor.ai into their curriculum lies

in the ability of cross-validation. Having two sample sizes or above will ensure reliability of the data collected and that it is not just a coincidence that Agor.ai has worked well with one particular institution and their students. In both of these institutions, the same subject's curriculum, such as history, economics, computing, foreign language studies, etc. will be targeted for the same reason. Since one of if not the best AI chatbot as of writing, OpenAI's ChatGPT achieves an accuracy rate hovering mostly at about 70-90% in similar subjects, we aim to surpass this as Agor.ai is trained and contextualised on a case-by-case basis according to the subject and curriculum.

The entire roadmap from design to launch should take about 2 years according to rough estimations, however can be subject to change.

5.2 Budget Plan

This budget plan details the estimated expenses for the development and deployment of the project. The budget accounts for the stages outlined in the business roadmap.

Item	Description	Estimated Cost (USD)
Research and Development	1. Development of the core AI engine based on Retrieval-Augmented Generation (RAG). 2. Data collection and preprocessing from diverse educational databases (e.g., Common Core, GCSE). 3. Collaborations with educators to curate curriculum-specific content for AI training.	$30,000
Technical Infrastructure	1. Subscription to cloud service providers (e.g., AWS, Azure) for hosting real-time interaction and storage. 2. Acquisition of software licenses for APIs including text-to-speech (TTS), speech recognition, and emotion detection. 3. Setup of secure databases for storing user interactions and learning analytics.	$25,000
Prototype Development	1. Creation of functional prototypes for student-facing avatar and teacher dashboard. 2. Integration of core features like interactive dialogue, real-time data visualization, and adaptive learning pathways. 3. Usability testing with internal teams and select external testers to refine features.	$15,000
Pilot Implementation	1. Deploying an alpha version of the system in small to medium-sized educational institutions. 2. Collection of qualitative and quantitative	$10,000

	feedback from students and educators via surveys and interviews. 3. Real-world testing of system scalability, functionality, and user engagement.	
Marketing and Outreach	1. Production of promotional materials including demo videos, brochures, and presentations. 2. Participation in academic conventions, techathons, and regional education expos. 3. Networking efforts to establish partnerships with initial target institutions.	$5,000
Operational Costs (Annually)	1. Recurring expenses for cloud computing resources to support the AI system. 2. Routine maintenance and updates for improving accuracy and expanding AI capabilities. 3. Dedicated technical support team for resolving queries from educational institutions and ensuring smooth system operation.	$20,000
Compliance and Security	1. Implementation of data privacy measures to comply with global standards such as GDPR and COPPA. 2. Regular security audits and penetration tests to safeguard sensitive educational data. 3. Obtaining certifications to enhance credibility and trust with stakeholders.	$8,000
Total		**$113,000**

5.3 Future Development

College and Universities

In the future, Agor.ai is set to expand its services to colleges and universities, marking a significant step in its mission to enhance educational support across all levels. This expansion aims to address the unique challenges faced by college students, such as time management, study skills, and fast access to resources. Agor.ai will provide personalized assistance, no longer do students need to navigate a few hundred page textbook to find the answer they seek; they need only ask Agor.ai.

As Agor.ai transitions into this new market, some changes to the avatar might be needed to make it more attractive to older students. One example is to allow Agor.ai to customize the avatar to popular celebrities in Hong Kong, although this will require some prior agreement with the celebrity involved due to legal issues.

The accuracy of the model will also need to be tested thoroughly as the stakes are larger in higher education, with the subjects also raising in complexity,

Quantitative Subjects

Although the current best large language models are still risky to be implemented in quantitative subjects such as mathematics and computer science, it might not take long for it to be. However, significant resources need to be spent to produce such a result - arriving at the correct answer does not indicate that all the prior steps in between are accurate or can be understood by students. This expansion into quantitative subjects might not be feasible until several years later.

International Expansion

So far, Agor.ai has only focused its services in Hong Kong. However, the problems that indicate the motivation to build Agor.ai is occurring worldwide; therefore many teachers and schools worldwide are experiencing similar problems and can benefit from Agor.ai in their curriculum. After starting operations in Hong Kong and staying there for a while, it should be relatively straightforward to expand into other parts of South Asia, particularly in places where there are many smaller sized schools with a large number of students seeking adequate education in developing countries. Some examples would be countries like Indonesia, India, Philippines, Malaysia, and so on with large populations.

6 Conclusion

In an era where post-pandemic barriers have led to significant declines in learning outcomes globally where both students and teachers are struggling, how can schools expect to raise a generation of talented students? Agor.ai is one such solution. Taking its name from the first classroom in Greece, Agor.ai aims to meet the needs of students, teachers, and stakeholders. With a subscription based model, all students can have a personalised tutor in their subjects, while alleviating the burden on the teachers' shoulders. By first designing the specific user requirements, close collaboration with the parties involved, and a continuous cycle of monitoring, analyzing, and refining, Agor.ai will be a state-of-the-art technology that will be irreplaceable in schools of the future. All it takes is 2 years of your support into our cause in changing the world for the better.

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