StudyGazelle : The next generation of education superpowered by Large Language Models

BUET GRC

Abstract— **In this white-paper, we propose a breakthrough in adaptive learning through streamlining the process of creating Pedagogical Conversational Agents(PCA). We also showcase the capabilities in pedagogical approaches based on different learner types through our user platform "StudyGazelle".**

I. PROBLEM STATEMENT

The emergence of AI has revolutionized several fields and has made new opportunities possible. This in turn has led to several industries growing at a massive pace. However, it is alarming to know that still today most of the ed-tech platforms are raised on static content that is the same for every user.

A. Learner Types

There are several methods that people learn. In other words, there are many types of learners :

- **Reading learners** - Learners who learn by reading
- **Aural learners** - Learners who learn by hearing
- **Visual learners** - Learners who learn by seeing
- **Kinesthetic learners** - Learners who learn by doing
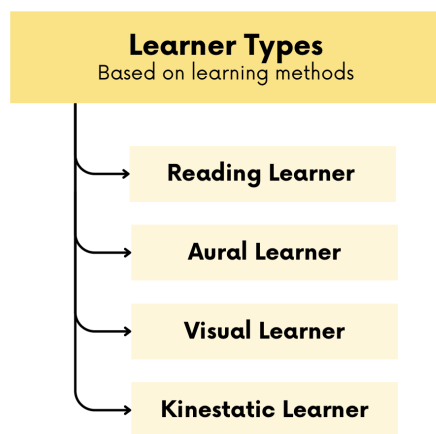
[10]

Fig. 1. Different Types of Learners

Other than these types, some other methods help different people learn better. Based on collaboration, there are several other types of learners:

- **Solo learners** - Learners who learn while being alone
- **Socio learners** - Learners who learn in a collaborative environment
- **Naturalistic learners** - Learners who learn whilst being in nature
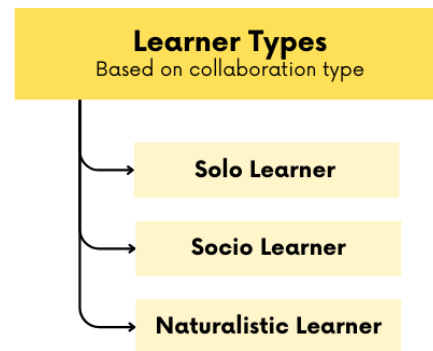
[10]

Fig. 2. Different Types of Learners based on collaboration

B. Emergence of Ed-tech Platforms

For the longest time our educational institutions were designed in a way that only helped Reading learners and Aural learners. Due to different constraints, traditional educational institutes were not able to go past that. After the emergence of the internet, a new type of educational platform arrived called "Ed-tech Platforms. These were able to take it one step above and expanded their horizon to visual learners as well.

C. Lacking of traditional Ed-tech Platforms

Some of the core problems of traditional Ed-tech platforms are as follows:

1) **Not being dynamic**
   The content generated by Ed-tech platforms are static and do not change for any user. This in turn means everyone gets the same. However, the learning level and education level of each person is not the same. This is one drawback of traditional platforms.

2) **Little to none collaboration is available**
   Most platforms don't have any means of collaboration between students. Some platforms provide communities; however, those are not enough for each user because the interaction is not real time. Students have to wait for a long time to get replies and it doesn't at all mimic real life.
3) **Classes do not change based on your learning level**
   The content in Atik platforms do not change based on what you have learned. It stays the same no matter how many times you come back and how many topics you have learned. This means, sometimes you have to learn the same thing all over again, although you have already learned it before.
4) **No way to iterate back if you don't understand a point**
   The contents and traditional platforms are designed such that you cannot go back to a particular point. If you don't understand a part of a video, you cannot go back and learn it again.

D. Probable reasons of these lacking

One of the core reasons that we find for our traditional ed-tech platforms to not being able to cater to other learner types is basically because they are simply **NOT ADAPTIVE**. Not being adaptive means that the content that they develop stays same for every one of their users. Irrespective of their :

- Skill Level
- Knowledge Level
- Pegagogical Goals etc.

This is one of the core reasons of why traditional ed-tech platforms are brutally failing.

II. VISION

Now to solve the issue of non-adaptive ed-tech platforms we come up with a proposal with transforming the existing systems and replacing or super powering them with the power of Artificial Intelligence.

A. Adaptive Learning

Adaptive learning is a combination of two things :
1) **Adaptability**
   Adaptability refers to manually adaptable settings selected by user preference
2) **Adaptvity**
   Adaptivity means the automatic adaptation to users according to changing conditions
[10]
These are the two things that if combined together or even implemented singly, has the ability to make the learning process adaptive to external variables.

There are four different variables that have been defined by pedagogical researchers to be responsible for adaptive learning systems. These are as follows :
1) **Affective** [Emotional State, Attitude etc.]

2) **Cognitive** [Skill Level, Learning Style, Cognitive Ability etc.]
3) **Motivational** [Individual Interest, Situational Interest, Goal Orientation etc.]
4) **Socio-Cultural** [Culture, Self-perception etc.]

[8] Though controlling these variables we can make our systems adaptive according to our pedagogical needs

Fig. 3.   Variables for adaptive learning

B. Pedagogical Conversational Agents(PCA)

Conversational Agents : Conversational Agents are simply agents that can interact with the users in natural language

Pedagogical Conversational Agents : Conversational agents that communicate intelligently and proactively, to remember learning statuses and progress, and to support the user's individual needs.

These are designed to develop adaptive learning systems.

C. Building PCA

PCAs are built using two common methodologies. Each having different ways to do that :

- **Pre-Configuration**
  1) Through a preset configuration; or
  2) Through a pre-test to assign learner to a particular level
- **Real Time Adaptivity**
  1) By collecting enough data about learner
  2) By monitoring real-time data (heart-rate, physical movement etc.)

D. Our proposal

We propose to create a three-fold system with 3 different platforms to make the PCA creation process streamlined and semi-automated. These are as follows :

1) Dataset Generation and Fine-tuning
2) Human Evaluation and Model Selection
3) Integration with multi-modal, multi-medium system for consumption

Let's discuss how we plan on doing each of the system in more details here :
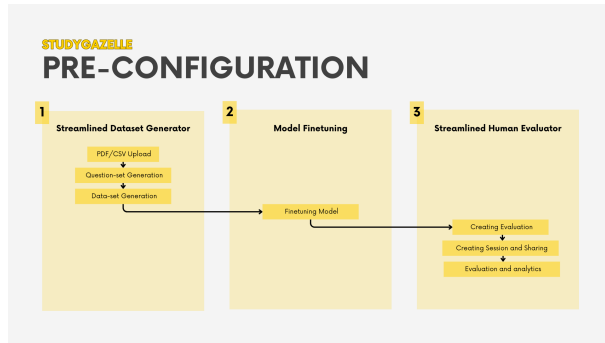
Pre-configuration

Fig. 4.   Our plan for adaptation through pre-configuration
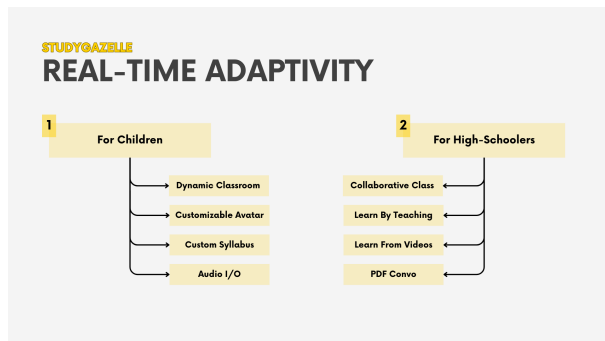
Real Time Adaptivity

Fig. 5.   Our plan for adaptation through real-time adaptivity

III.   USE CASE AND EXISTING SOLUTIONS

A. Use Cases

We can categorize the use-cases by target audiences. We have jotted down the target audience to be from 3 different segments. Students, Teachers and Experts.

1) For Students: We have divided the students into two further categories :

- **Children**
  For children we have planned four use-cases in mind

  1) **Dynamic Classroom**
     A classroom with modifiable features that can be modified before starting the lectures
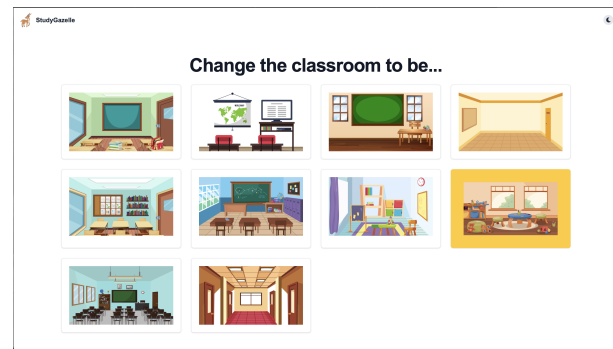

Fig. 6.   Dynamic Classroom

2) **Customized Avatars**
   There can be a modifiable character who's appearance as well as voice can be changed
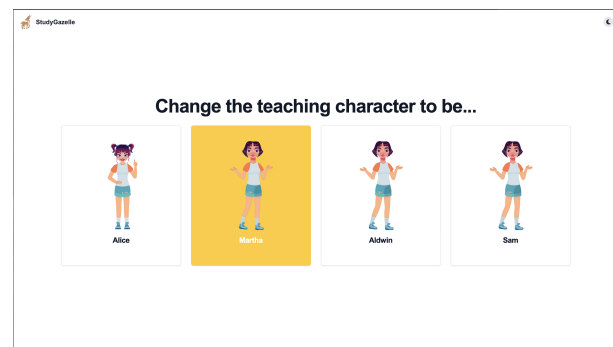

Fig. 7.   Customized Avatars

3) **Customized Syllabus**
   There can be customized syllabus for our end users so that they can choose what they learn
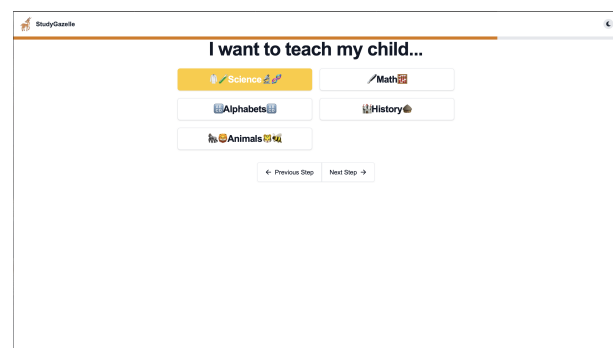

Fig. 8.   Customized Syllabus

4) **Multi-modal input and output for better interactivity**
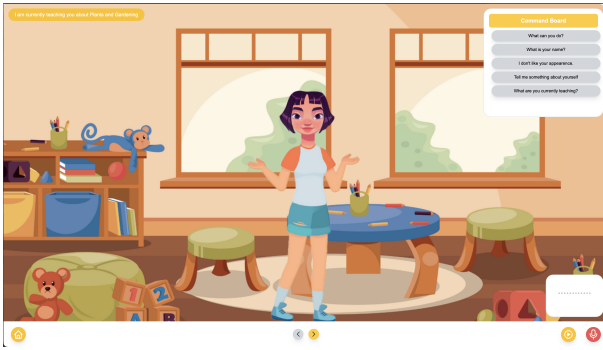   The input and output can be in the form of audio/video instead of just textual input/outputs

Fig. 9. Multi-modal input and output for better interactivity

- **High School Students**

  1) Collaborative Classroom
     Where students can join like in a zoom call and have group chat with LLM Support
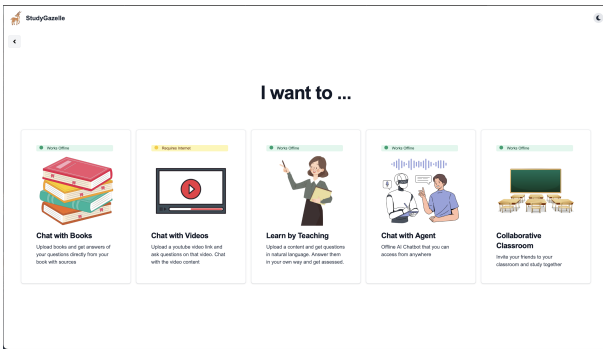

Fig. 10. Market regions in Ed-tech industry

  2) Learn By Teaching
     This procedure was made by following Ruffle and Riley [9] where there would be two agents in a class setting; one is a student bot who asks the learner questions. And the other is a teacher bot who teaches the learner about that topic.
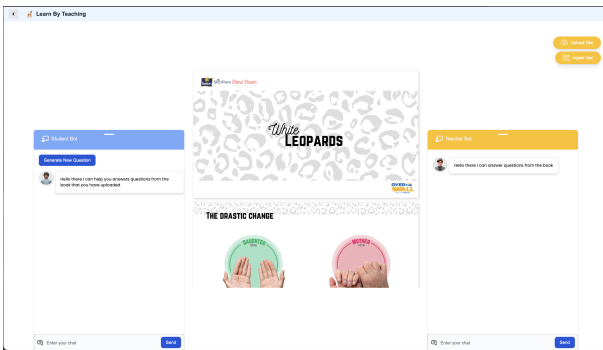

Fig. 11. Market regions in Ed-tech industry

  3) Learning from videos
     Learners can have chat with video transcriptions to have another mode in visual learning setting
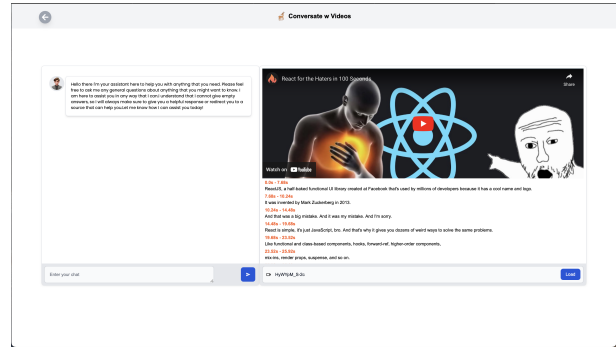

Fig. 12. Market regions in Ed-tech industry

  4) Learning from PDF
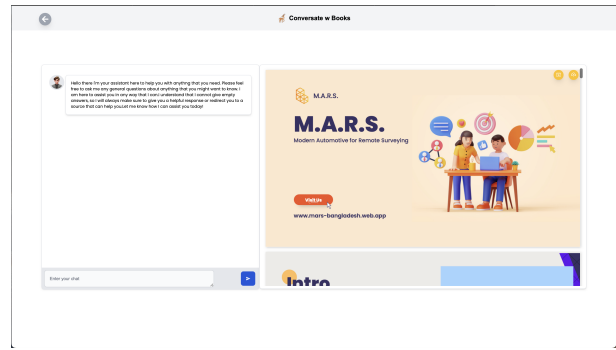   Learners can have faster transfer of knowledge by chatting instead of reading the whole book

Fig. 13. Market regions in Ed-tech industry

2) For Teachers: For teachers we can make the platform adaptive by letting them create study materials faster. This can be done by:

- Create questions
  Teachers would be able to create custom questions from existing knowledge source adaptively
- Flashcard generation
  Creating dynamic flashcards can also be a feature that can help with adaptive learning

3) For Experts: Experts can be benefited by this platform through the use cases of

- Generating Datasets
  Our platforms can help them generate dataset for their particular use case
- Human Evaluation
  They can do human evaluation with our system in a faster and much more intuitive manner

B. Market Size of Ed-tech Industry

The global education technology market size was estimated at USD 142.37 billion in 2023 and is expected to grow at a CAGR of 13.4% from 2024 to 2030. [3]

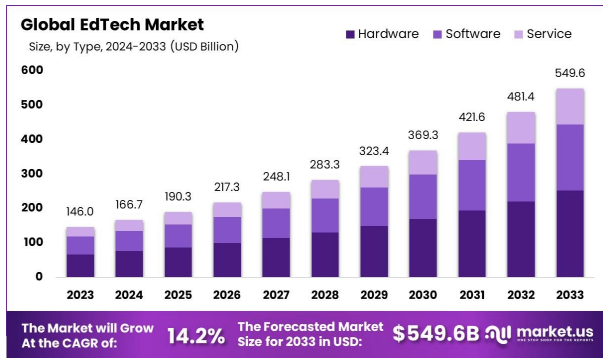According to one source it is shown that the market is growing exponentially. [6]

Fig. 14. Market growth in Ed-tech industry

The global ed-tech market has two main modalities of functionality.

1) Cloud
2) On Premise

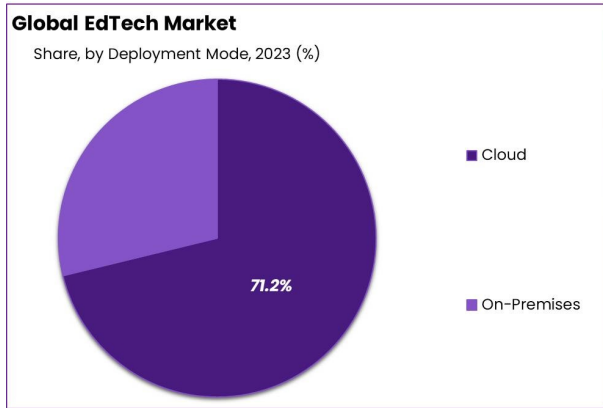Cloud has 71.2% of the total market share whilst the On premise hold just 28.8% of the total market. [6]

Fig. 15. Market segments in Ed-tech industry

The ed-tech industry market can be divided into 5 different regions as follows [6] :

1) North America
2) Latin America
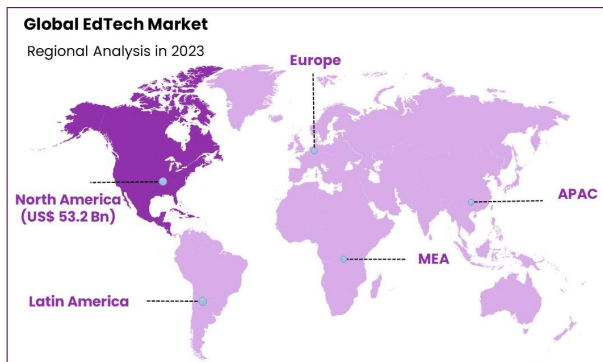3) Europe
4) MEA
5) APAC

Fig. 16. Market regions in Ed-tech industry

C. Existing Solutions

Here is a list of current existing solutions. We also briefly discuss their shortcomings and features as well

Name	Core Features	Shortcomings
Coursera	• Wide range of courses • University partnerships • Certificates and degrees	• Limited interaction with instructors • Some courses lack depth • High cost for certificates
Udemy	• Diverse course topics • Affordable pricing • User-created content	• Inconsistent course quality • Limited academic credibility • No degree programs
Khan Academy	• Free content • K-12 focus • Interactive exercises	• Limited advanced topics • No certifications • Less structured learning paths
edX	• University-level courses • MicroMasters programs • Non-profit organization	• High costs for verified certificates • Less frequent course starts • Limited mobile app functionality
Duolingo	• Gamified language learning • Free basic version • Mobile-friendly design	• Limited advanced language content • Lacks formal grammar instruction • Not suitable for all learning styles

Fig. 17. Our plan for adaptation through real-time adaptivity

[4] [7] [5] [2] [1]

IV. RISKS AND CHALLENGES

A. Risks

Some of the risks and challenges of our applications include:

- API costs being expensive
- User base is being too large
- Catering to different communities
- Steep learning curve

B. Mitigation

To mitigate the aforementioned challenges, we propose the following suggestions :

- Providing local models to keep it cheap for students who do not want to pay as much
- A separate platform can be developed for children, so that our user base is manageable
- Since we're catering to different communities category based dashboards can be made for them so that they only see the features they need.
- Provide tutorials for our platform so that new users can know how to use our platform

V. ARCHITECTURE AND INFRASTRUCTURE

There are in total 3 components of our whole system. Each of them have been developed as a separate platform. These are as follows:

1) S.A.L(Streamlined Automated LLM) Dataset Generator
2) S.A.L(Streamlined Automated LLM) Human Evaluator
3) StudyGazelle

We will talk about the architecture of each of them seperately

A. S.A.L(Streamlined Automated LLM) Dataset Generator

We will review all of these with a few sequence diagrams:
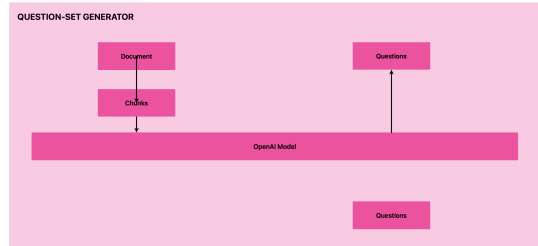
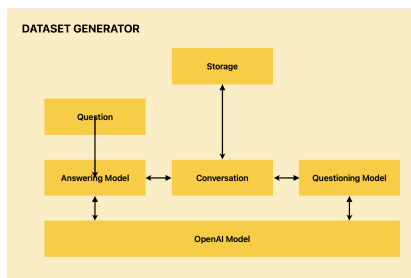**Components**

Fig. 18.   Question Set Generator Engine

Fig. 19.   Dataset Generator Pipiline
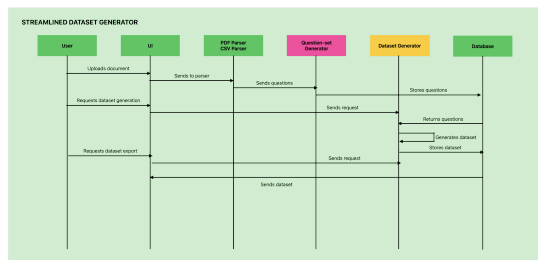
Full Platform

Fig. 20.   Market regions in Ed-tech industry
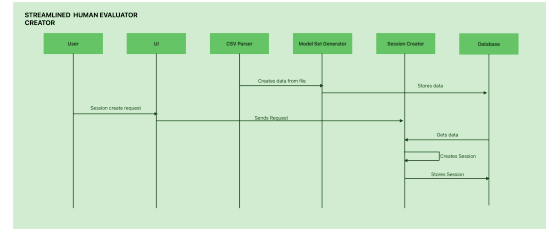
B. S.A.L(Streamlined Automated LLM) Human Evaluator

For Experts

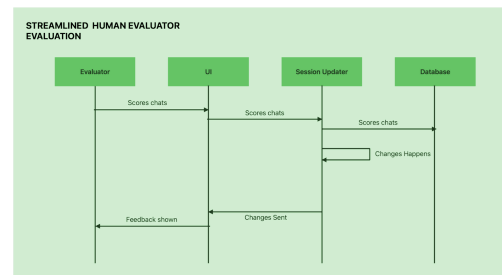Fig. 21.   Pipeline for creating evaluations and sessions

For Evaluators

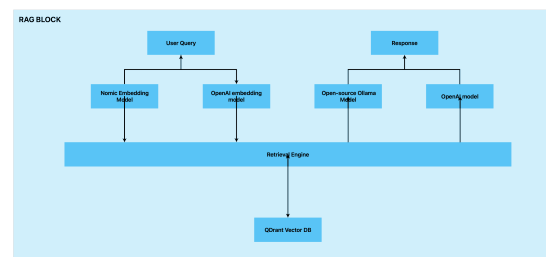Fig. 22.   Pipeline for evaluation in a session

C. StudyGazelle
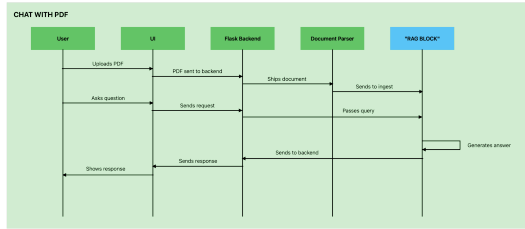
Components

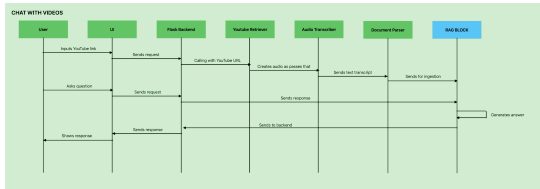Fig. 23.   Market regions in Ed-tech industry

RAG Block Sequence Diagram

Fig. 24.   Chat with books pipeline

Fig. 25.   Chat with videos pipeline

D. Technologies Used

These are the technologies that have been used to develop the platforms

CATEGORY	TECHNOLOGY
Frontend	React
Mobile Application	Flutter
UI Library	Flowbite
Icons	Flaticons
LLM Models	GPT-3.5, Gemini-1.5, Claude 3.5, llama3
Embedding model	nomic, text-embedding-3
Vector database	Qdrant
MLops	Langchain
Analytics	Langsmith
Authentication	Firebase auth
Database	PostgreSQL
REST API	FastAPI

Fig. 26.   Technology stack in all our applications

VI.   REVENUE AND DISTRIBUTION

A. Revenue model

Our model will have a B2B and a B2C revenue model. For the B2C model the pricing would be as follows:

Plan	Price per month
Basic	$5
Pro	$20
Supreme	$50

Fig. 27.   Pricing Plan

For our B2B partners, we would provide up to 50% discount.

B. Distribution plan

We have come up with a one year plan of operations for our product. This is briefly discussed as follows :

Quarter 1

- Begin the expansion phase by targeting schools, colleges, and universities.
- Showcase the product and secure B2B partnerships.
- Aim to reach 10,000 users by visiting 50 educational institutions.
- Expected monthly revenue target: $100,000.

Quarter 2

- Focus on customer retention by offering improved pricing and features.
- Ensure existing customers remain engaged.
- Rely on word-of-mouth marketing to attract new users, reducing marketing expenses.

Quarters 3 and 4

- Expand globally and target a larger audience.
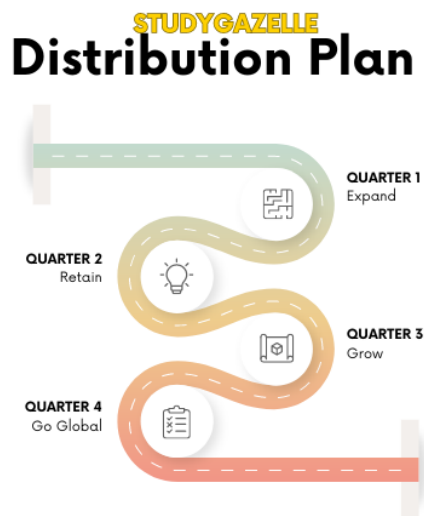- Elevate the application to a new level.

Fig. 28.   Our 1 year distribution plan for StudyGazelle

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[2] Anonymous. edx, 2024. Accessed: 2024-08-29.
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[6] Anonymous. market.us, 2024. Accessed: 2024-08-29.
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[9] Robin Schmucker, Meng Xia, Amos Azaria, and Tom Mitchell. Ruffle&riley: Towards the automated induction of conversational tutoring systems. *arXiv preprint arXiv:2310.01420*, 2023.
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