Eureka - يُريكَ

AI Driven Interactive Self Learning and Assessment Platform

منصة تعليم ذاتي تفاعلية و اختبارات الكترونية مدعومة بالذكاء الاصطناعي

Chapter 1

1.1 Introduction

The right to free and accessible education is considered a human right under Article 26 of the Universal Declaration of Human Rights[1]. Yet the article does not specify the quality of education given. Many nations, especially those with limited resources, allocate the minimum needed to maintain public schools. As a result, schools are usually uninviting to students, teachers don't get paid enough and have little incentive to work and teach, and the education system, rather than producing a mind capable of critical thinking and problem solving, produces a mind that knows what it learned but not how to use it.

Globally, there is a clear pattern linking national wealth to educational quality.[2] Take Finland, the Netherlands, and the United States as examples. They consistently manage to stay on top of education rankings and produce some of the most skilled people and researchers in the world. On the other hand, nations with less wealth struggle to provide the same level of educational opportunities to their citizens, and even those who manage to access high-quality education often travel abroad to wealthier nations, contributing to what is known as "brain drain."[3]

China, despite being far less wealthy in previous decades, invested heavily in education as a strategic national priority. Over time, the country transformed its massive human capital from a burden into a key economic and developmental engine.[2], [4] This shows that even countries with limited resources can invest in education and develop significantly, but not every nation has the capability to follow this path. Countries dealing with other priorities or debt often find it

difficult to allocate enough funds to education.

Egypt faces a problem with parallel education systems such as private tutoring, which is usually very expensive for most Egyptians. Many teachers don't perform their job well at school but instead rely heavily on private tutoring to make enough income. Over time, private tutoring has become a central and costly part of education, putting pressure on families and reducing the effectiveness of formal schooling. Students and parents are conditioned to believe that tutoring is necessary to achieve good grades, and the lack of alternative options has created a kind of monopoly around it.[5], [6]

Improving the quality of education in Egypt is becoming more urgent every year. Families are spending more than they can afford, students are relying on tutoring instead of actual learning, and the gap between those who can pay and those who cannot keeps growing.

Traditional methods alone are no longer enough, especially with crowded classes, limited school resources, and the increasing financial pressure on teachers. There is a clear need for new approaches that can support students in a more flexible and affordable way while still giving them a real chance to understand, practice, and build skills without depending on private tutoring.

The next section discusses the main problems in the current system and the specific issues this project aims to address.

1.2 Problem Statement

Education in Egypt has been concerned with studying for a final exam throughout the entire school year. Usually students and teachers treated the lessons as something to be memorized

1.3 Objectives

Eureka aims to provide a smart, adaptive, and personalized self learning system that helps students learn on their own. Eureka is designed for the Egyptian curriculum in mind whether it's schools or universities. The platform utilizes advanced A.I algorithms such as spaced repetition algorithms to improve retention and keep students focused on what they need to learn. Questions are designed to be interactive so that the students not just know what the answer is, but why that

is the answer. Alongside this, teachers can also create their own questions, explanations and exams utilizing the same framework as the students making Eureka both a self learning and an assessment environment.

1.3.1 Functional Objectives

- Attract students using gameification methods such as leveling progress, points and rewards based on their performance.
- Implement spaced repetition to help students focus only on what they struggle on and improve their memory retention.
- Utilizing spaced repetition, store solved questions and mistakes in review queues so that the student can always revise their mistakes.
- Provide interactive questions to help students build their intuition and problem solving skills.
- Offer lesson explanations via text and videos that teach the student just enough to start solving.

- Support interactive essay-style questions using interactive nodes to build complex answers intuitively.
- Generate questions based on student performance and what they are struggling on.
- Include an A.I chatbot to help students understand their mistakes and if they have any questions in the lessons.
- Allow teachers to create classes which will include exercises, lessons, and quizzes using the same interactive framework.
- Provide a secure online exam environment with A.I proctoring and computer vision to prevent cheating.

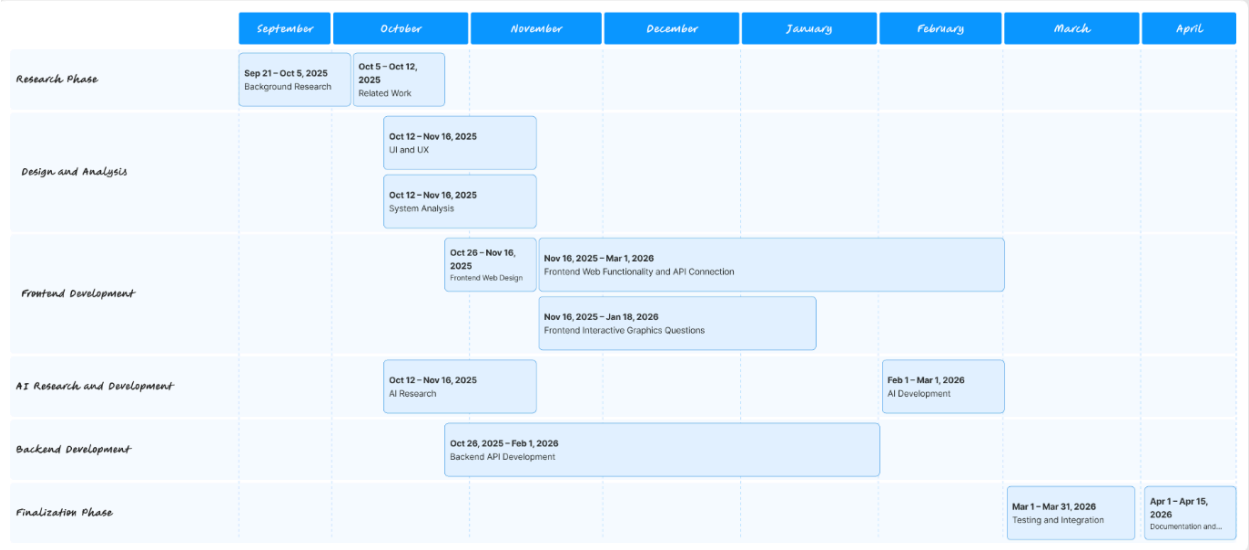
1.3.2 Non Functional Objectives

- Provide an intuitive and easy to use interface so students can learn with minimal distraction and find what they need quickly.
- Maintain a slight and calm gameification style that is not too addictive.
- Support both Arabic and English to make platform accessible for all students.
- Platform must be affordable and use a freemium model to ensure all students can use it.

1.4 Project Scope

The scope of this project is to build a web prototype of an interactive self learning platform focused on the Egyptian high school curriculum and computer science subjects. The MVP will include core features such as spaced repetition, adaptive questions generation, interactive questions, lesson explanations and gamification elements. It will also support teachers through teacher created classes where they can create lessons, exercises and online exams. Exams will be secure and utilize AI proctoring techniques to limit cheating to a minimum. The goal is not to cover the full curriculum but to build a prototype that showcases how efficient the platform could theoretically be.

1.5 Project Timeline



Chapter 2 Literature Review

2.1 Educational Challenges in Egypt

Education in Egypt has been suffering due to the same problems for decades, and most of them are directly tied to how the system works in practice. Even though education is technically free and accessible, the quality of the learning experience is far from equal for most students. Public schools struggle with overcrowded classrooms, limited resources, and a curriculum that leans heavily toward memorization instead of real understanding. Teachers are often expected to manage classrooms with 40–50 students and outdated materials, which makes proper teaching almost impossible.

2.1.1 The Phenomenon of Tutoring

For many school teachers in Egypt, the reality is that salaries have not kept up with the rising cost of living. Without enough income to support their families, many educators are forced to look for other ways to make ends meet. As a result, private tutoring has become the standard solution, with nearly every teacher and even some unlicensed individuals offering lessons at various price points.

This tutoring market generally splits into two categories based on what a family can afford:

Private and Small-Group Sessions The most effective option is private tutoring, where a student works one-on-one with a teacher. This allows the teacher to personalize the learning experience that satisfies the student's needs while giving them as much attention as possible. However, this personalized experience is expensive and out of reach for most Egyptian families. To make this more affordable, students often form small groups with friends, splitting the cost of the tutoring fee while still getting some level of personal attention.

Public Tutoring Centers Students who cannot afford private sessions usually resort to "centers" or public tutoring classes. These are often large lecture halls packed with students, resembling a crowded school classroom more than a private lesson. In these centers, teachers explain the material, assign homework, and give exams which are tasks they are supposed to do in school. However, because the pay from these centers is significantly higher than their salary, teachers naturally invest more energy and effort into these paid sessions than their regular school classes.[6]

2.1.2 Overcrowded Classrooms & Under-Resourced Schools

One of the biggest challenges in public education in Egypt is the sheer number of students inside each classroom. Many government schools operate far beyond their intended capacity. It’s not

uncommon to find 40, 50, or even more students squeezed into one room, making it nearly impossible for teachers to give personal attention to anyone. The classroom environment becomes noisy, crowded, and uncomfortable, and most teachers end up explaining the lesson once and hoping that everyone understood.

On top of that, a lot of schools lack basic learning tools. Some schools don’t have functioning labs, proper libraries, or even enough chairs. Technology is limited, and most classes rely only on a chalkboard. Even teachers who genuinely want to help students are restricted by the conditions around them. The result is a system that struggles to support real learning, especially for students who need extra help or a different style of explanation.

2.1.3 Rote Learning & Exam Culture

The system's reliance on a single final exam is another issue. Students learn early on that the goal of education is to memorize the material required to pass the final exam rather than to comprehend. Instead of teaching students how to think, teachers frequently drill them with model answers under pressure from the system and parents' expectations.

As a result, many students graduate from school lacking genuine problem-solving abilities and self-assurance. Instead of learning "why" the answer is right, they learn "what" it is. There is very little opportunity for creativity, critical thinking, or curiosity in this method. Learning becomes a stressful routine rather than something meaningful when the entire year is focused on memorization.

This exam pressure is one of the reasons tutoring became such a dominant part of student life in the first place.

2.1.4 Inequality & the Financial Burden on Families

Although education is supposedly free in Egypt, most families find it to be very costly. A significant amount of the average household income is spent on tutoring, particularly during the last years of education. Families frequently believe they have no choice but to spend more than they can afford because the educational system is insufficient to guarantee high grades.

There is a significant divide between the students as a result. Individualized explanations and practice are provided to those who can afford private tutoring. People who can't afford it frequently rely solely on packed schools and public tutoring facilities, which puts them at a disadvantage.

This inequality ends up affecting students’ confidence, performance, and opportunities later in life. It perpetuates a cycle in which academic achievement is determined by financial capacity.

2.1.5 Technology Gaps & Lack of Interactive Learning

Egyptian schools still mainly rely on printed handouts and chalk-and-board explanations, even though many other nations are embracing digital learning tools, interactive content, and contemporary teaching techniques. Seldom do students have the opportunity to investigate ideas through simulations, visualizations, or practical problem solving.

Even when learning platforms do exist, they frequently consist of collections of videos or multiple-choice questions rather than actual interactive experiences. Students find it challenging to develop deeper understanding or intuition as a result. When students are unable to "see" or engage with concepts, subjects like physics, chemistry, and mathematics become even more challenging.

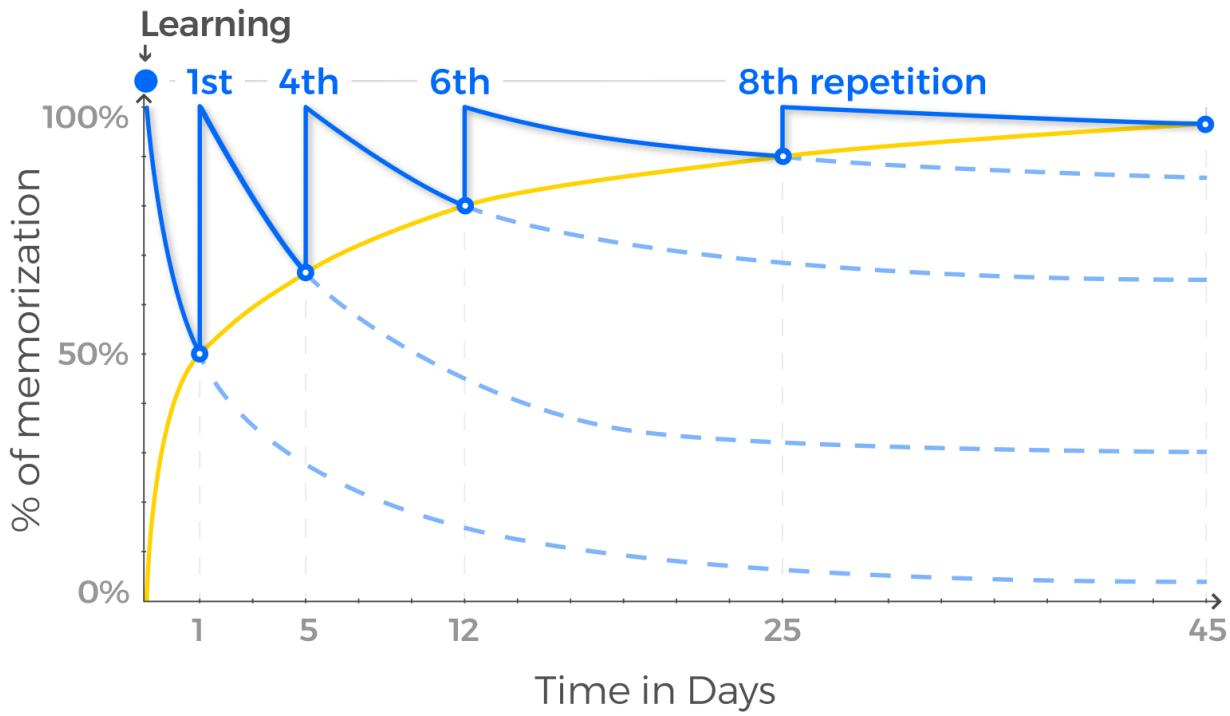
This disparity demonstrates the obvious need for resources that support students' learning in a more contemporary and interesting manner.

2.2 Theoretical Background

To address the problems outlined in the previous section, specifically rote memorization and the lack of engagement. Eureka relies on established educational theories and cognitive science principles. The proposed solution is not just about digitizing a textbook; it is about fundamentally changing how information is processed, retained, and visualized by the student.

2.2.1 The Forgetting Curve and Spaced Repetition

One of the most persistent issues in the traditional Egyptian education system is the "cramming" culture. Students often memorize massive amounts of information days before an exam, only to forget nearly all of it shortly after. This phenomenon was first mathematically quantified by the German psychologist Hermann Ebbinghaus in 1885.[7]



Ebbinghaus demonstrated that memory follows an exponential decay curve. Without review, learners forget roughly 50% of new information within a day and up to 90% within a week (Ebbinghaus, 1885/1913). However, this decay can be interrupted. By reviewing the material at increasing intervals just as the brain is about to forget it the "forgetting curve" is flattened, and the memory is strengthened. This technique is known as **Spaced Repetition**.

Research by Cepeda et al. (2008) confirms that spacing out study sessions (distributed practice) produces far superior long-term retention compared to massed practice (cramming), even when the total study time is the same. By implementing spaced repetition algorithms, the platform shifts the student's focus from short-term storage for an exam to long-term retention for actual knowledge building.[8]

2.2.2 Active Recall vs. Passive Review

Most students instinctively study by re-reading their textbooks, highlighting notes, or watching video lectures. While these methods feel productive, they are classified as "passive review." They create a phenomenon known as the "illusion of competence," where a student recognizes the material and assumes they know it, but cannot reproduce it on their own.

In contrast, **Active Recall** involves retrieving information from memory without looking at the source material. This is often achieved through self-testing or answering questions before looking at the solution. Roediger and Karpicke (2006) famously demonstrated the "Testing

Effect," showing that students who studied by taking practice tests outperformed those who simply re-studied the material, even when the re-studiers spent more time with the content.[9]

Eureka leverages this by ensuring that the primary interaction is not reading, but solving. By forcing the brain to work to retrieve the answer, the neural pathways associated with that information are strengthened significantly more than by passive observation.

2.2.3 Interactivity and Constructivist Learning

In subjects like physics, mathematics, and computer science, knowing the definition of a concept is not the same as understanding how it works. Static text and even video lectures often fail to convey the dynamic nature of these systems.

This project adopts a **Constructivist** approach to learning, a theory championed by Jean Piaget, which suggests that learners construct knowledge through experience and interaction rather than just passively receiving it. In the context of digital education, this is achieved through interactive simulations and visualizations.[10]

Research into multimedia learning supports the idea that people learn better from words and pictures than from words alone, specifically when the learner can control the pace and manipulate the variables. By allowing students to interact with the parameters of a problem, such as changing the mass in a physics simulation or modifying code in a CS lesson, they develop an intuitive "feel" for the subject that static memorization cannot provide.[11]

2.2.4 Gamification and Motivation

Finally, an educational platform is only effective if students are motivated to use it. **Gamification** is the application of game-design elements, such as points, levels, and progress bars in non-game contexts to drive user engagement.

However, effective gamification must go beyond simple badges. It relies on **Self-Determination Theory (SDT)**, which posits that human motivation is driven by three needs: competence (feeling capable), autonomy (feeling in control), and relatedness (feeling connected) [12]

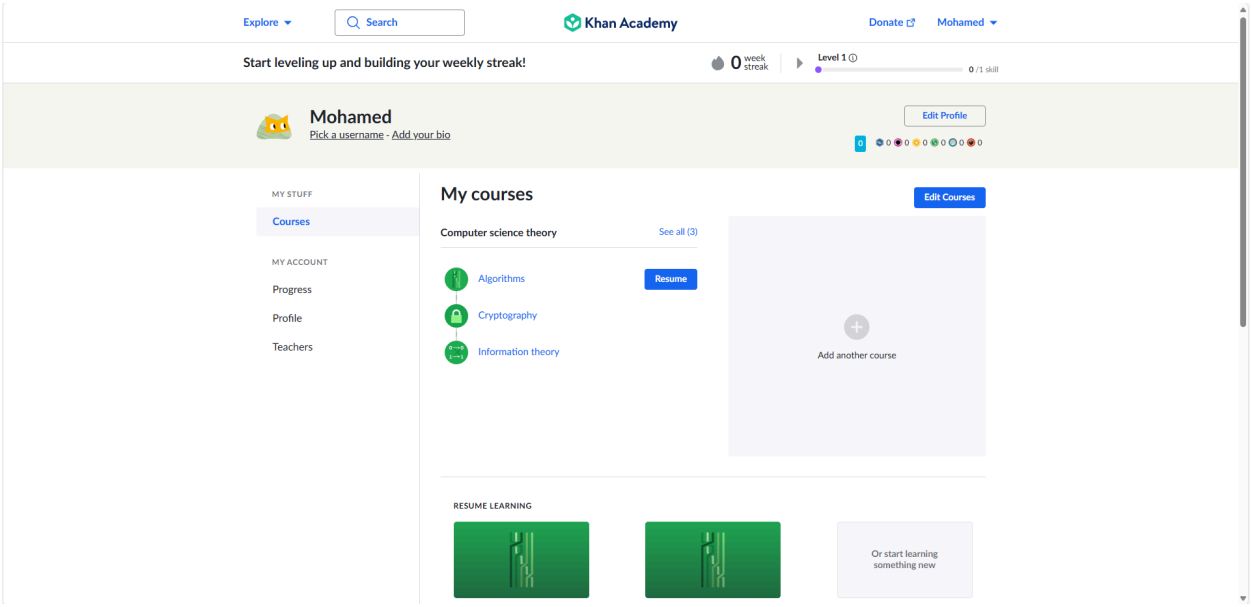
In Eureka, gamification is designed to satisfy the need for competence. Instead of punishing mistakes, the system visualizes progress and mastery. When a student sees a visual representation of their knowledge "leveling up," it triggers a dopamine response similar to video games, but directed toward productive learning. This keeps the student in a state of "Flow" [13], where the challenge of the material is perfectly balanced with their current skill level, preventing both boredom and anxiety.

2.3 Related Work

The landscape of digital education platforms is vast. Lots of platforms offer different ways on how to achieve effective education.

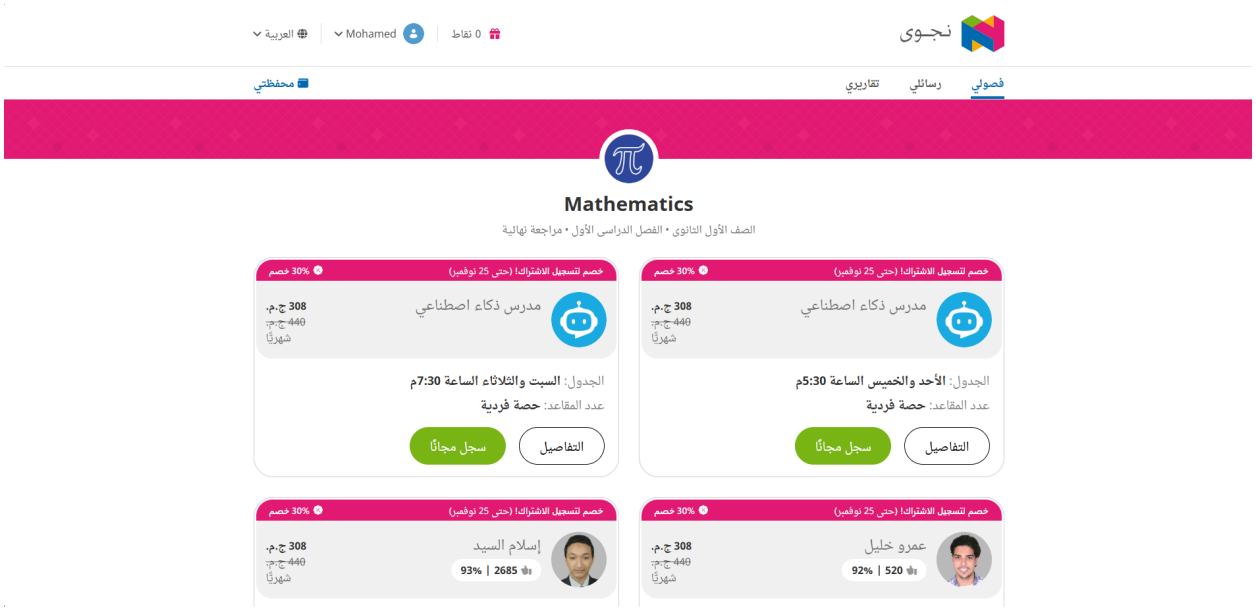
2.3.1 Traditional and Video-Based Curriculum Platforms The dominant model in online education remains the "digitized classroom," where traditional lectures are replaced by pre-recorded videos, followed by standard multiple-choice questions (MCQs).

Khan Academy



Khan Academy is the global exemplar of this model, offering a vast library of high-quality, free video lessons across STEM subjects. While excellent for initial concept introduction, its reliance on passive video consumption does not actively combat the "illusion of competence." Students often watch a video and feel they understand, but struggle to apply the knowledge later due to a lack of active, scaffolded practice.

Nagwa

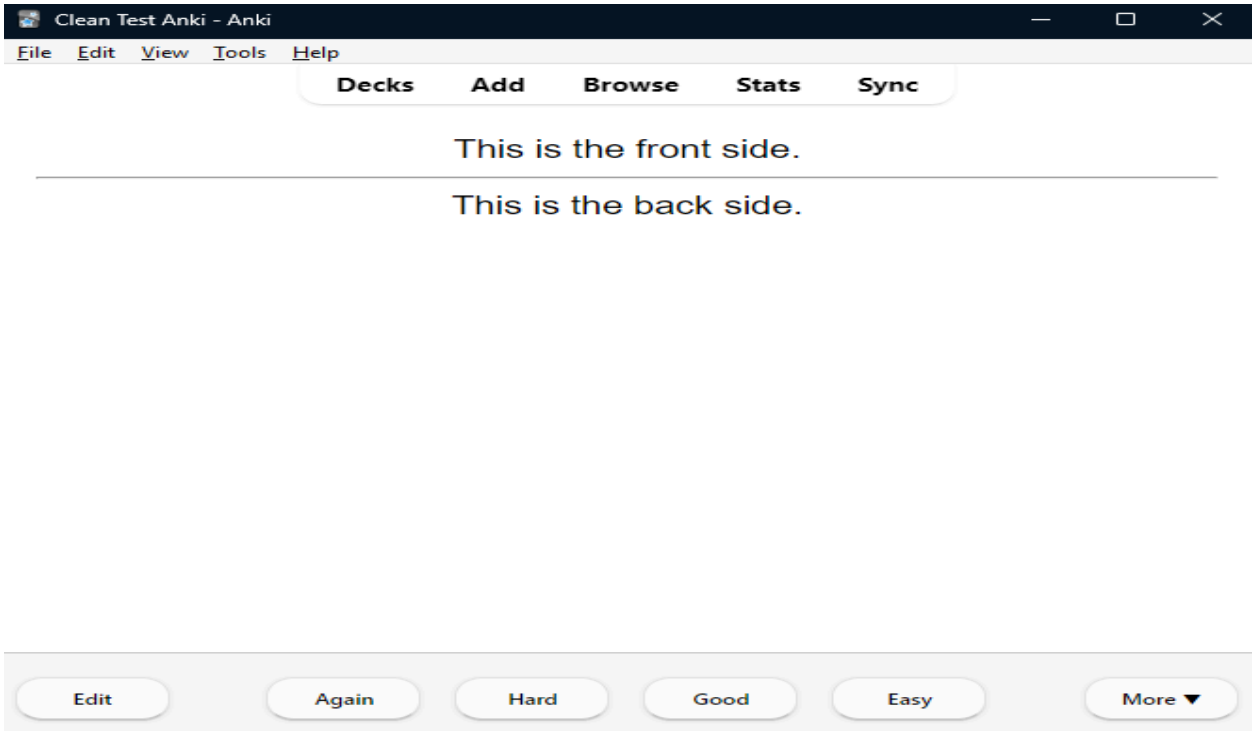


Nagwa is a major player specifically in the Egyptian market, providing curriculum-aligned content in Arabic and English. Its strength lies in its localized content library and direct relevance to Egyptian national exams. However, like Khan Academy, its primary pedagogical mode is video delivery and standard worksheets. It digitizes the traditional Egyptian method of lecturing rather than fundamentally transforming it into an interactive, inquiry-based experience.

While these platforms solve the issue of content *access*, they do not sufficiently address the issue of deep *engagement* or long-term retention through mechanisms like spaced repetition.

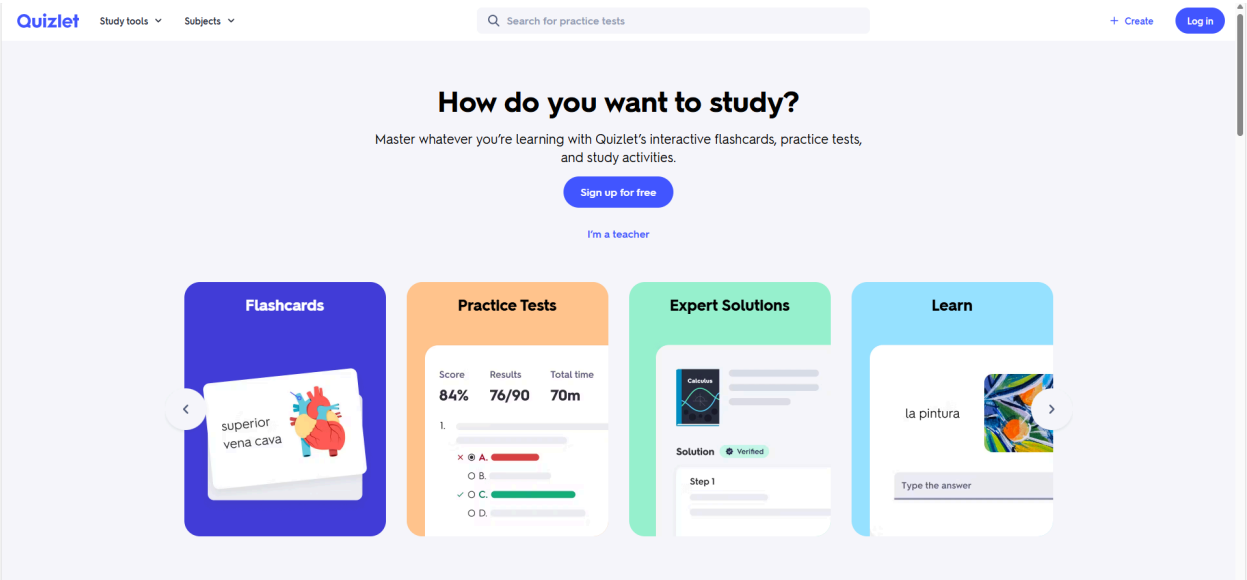
2.3.2 Dedicated Spaced Repetition Systems (SRS) Recognizing the inefficiency of cramming, several tools focus exclusively on optimizing memory retention through the spacing effect.

Anki



Anki is considered the gold standard for spaced repetition algorithms. It is highly effective for long-term memorization of facts, definitions, and syntax. However, Anki is a "blank slate" tool; it relies entirely on user-generated content. Creating effective flashcards for complex subjects like physics or computer science requires significant effort and skill from the student, creating a high barrier to entry. Furthermore, it lacks any curriculum structure or teacher oversight.

Quizlet



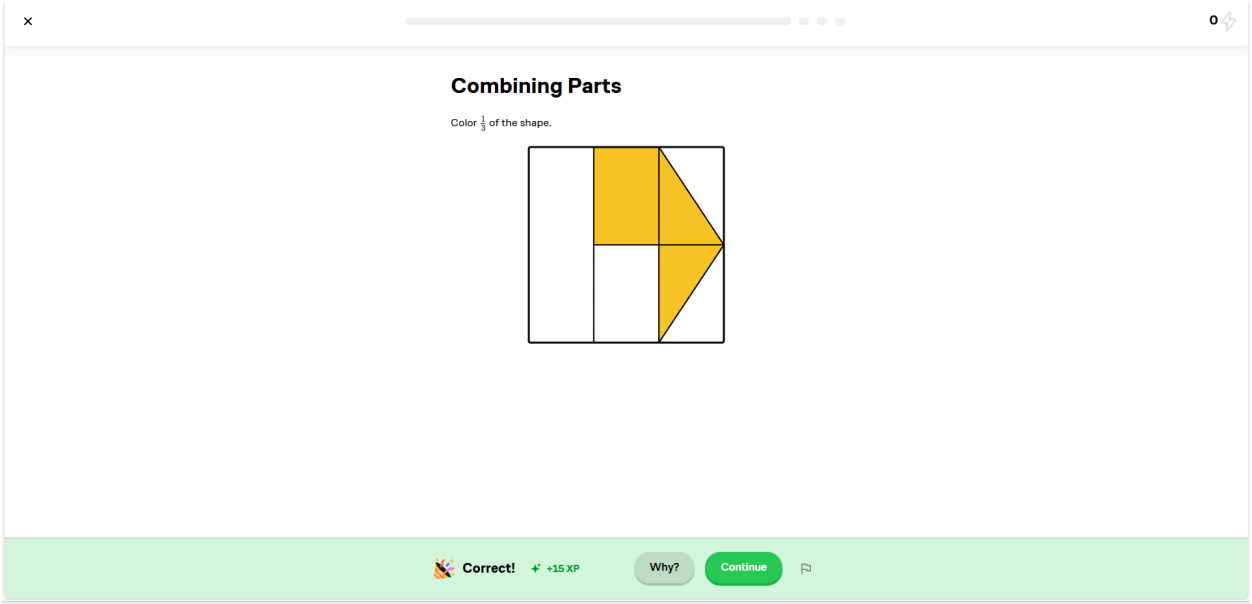
Quizlet offers a more accessible entry point to digital flashcards with some gamified elements. While easier to use than Anki, its review algorithms are generally less robust, and its primary mechanic remains "flipping cards," which is less effective for building complex mental models than solving interactive problems.

These tools excel at *retention* but lack the *instructional scaffolding* necessary to teach new, complex concepts from scratch in a structured academic setting.

2.3.3 Interactive and Constructivist Platforms

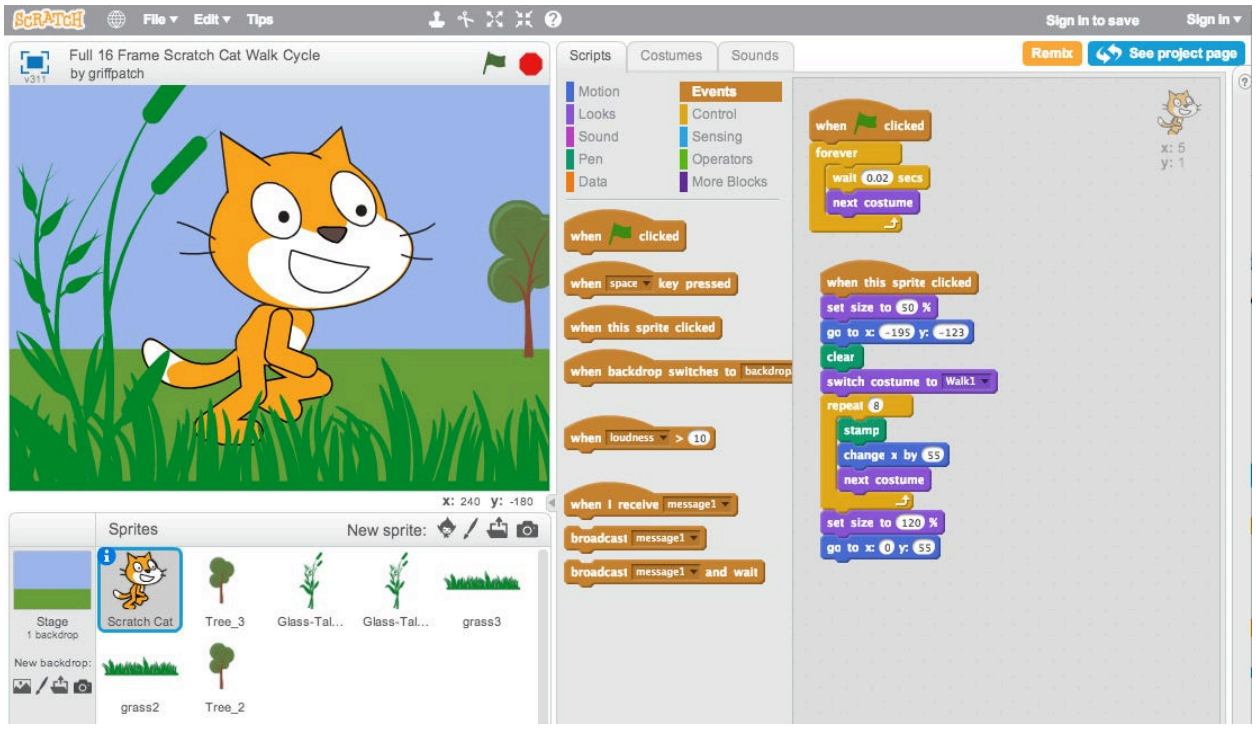
Moving beyond passive videos and simple recall, some platforms focus on building intuition through active participation and interactivity.

Brilliant.org



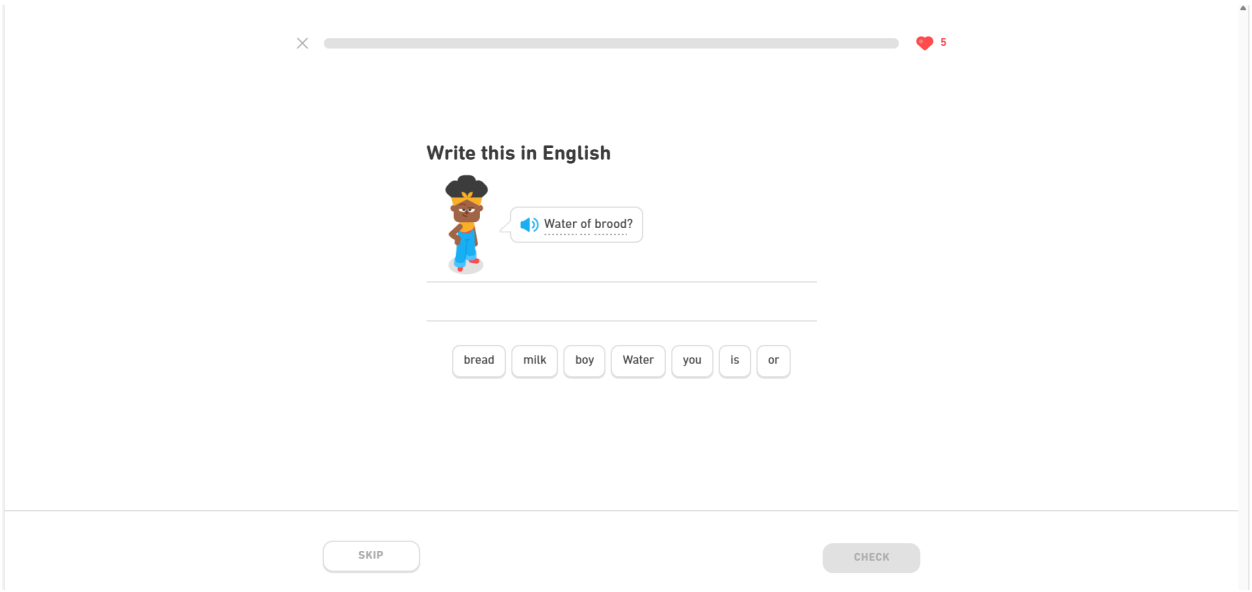
Brilliant stands out for its approach to teaching STEM through interactive puzzles and guided problem-solving rather than lectures. This builds excellent intuition and aligns well with constructivist learning theories. However, Brilliant operates outside of standard school curricula; it teaches concepts broadly but does not prepare students for specific national exams. It also lacks instructor-led features for classroom integration.

Scratch



Scratch (developed by MIT) is the prime example of constructionist learning in computer science, allowing students to learn by building projects. While powerful for fostering creativity and basic logic, it is an open-ended sandbox environment, lacking the structured progression, assessment metrics, and review mechanics needed for a comprehensive self-learning platform specifically for high school curriculum obligations.

Duolingo



Duolingo has successfully masterminded gamified learning, using short, interactive exercises and strong competence-based motivation (levels, streaks) to maintain engagement. While highly successful for language learning, its format of "bite-sized," repetitive translation tasks does not translate well to deeper, hierarchical subjects like physics or advanced algorithms, which require deeper sustained focus and complex problem visualization.

2.3.4 Summary and Gap Analysis

The review of existing platforms reveals a fragmented landscape. Students in Egypt currently have to fragment their learning process: watching video explanations on one platform (Nagwa/Khan), trying to memorize facts on another (Anki), and perhaps seeking intuitive understanding on a third (Brilliant)—all while likely still paying for private tutoring to connect these pieces for the final exam.

There is a clear absence of a unified platform that combines **curriculum alignment** (specifically for Egypt) with high-fidelity **interactive learning mechanics** (beyond simple MCQs) and integrated **spaced repetition** for long-term retention. Furthermore, few platforms effectively bridge the gap between self-learning and institutional education by offering robust teacher tools within the same ecosystem.

Table 2.1 summarizes comparison between major educational platforms and the proposed Eureka system across key pedagogical and technical dimensions.

Eureka aims to fill this gap by synthesizing the strengths of these different approaches: adopting the curriculum focus of Nagwa, the interactivity of Brilliant, the retention mechanics of Anki, and the motivational structure of Duolingo, all within a single, bilingual ecosystem designed for the Egyptian context.

Platform	**Primary Focus/ Market**	**Self Learning Approach**	**Curriculum Alignment (Egypt)**	**Interactivity Level**	**Spaced Repetition (SRS)**	**Teacher & Classroom Tools**	**Bilingual Support (Ar/En)**
Khan Academy	Global K-12 & Test Prep	Video Lectures + Standard MCQs	No	None	No	Yes	Limited
Nagwa	Egypt	Video Lectures + MCQs + Online Tutoring	Yes	None	No	Yes	Yes
Anki	Global Lifelong Learners	User-Generated Flashcards (Memorization)	No	None	Yes	No	Yes
Quizlet	Global Students	Digital Flashcards & Simple Games	No	Low	Yes	Yes	Limited
Brilliant	Global STEM Enthusiasts	Guided Interactive Problem Solving	No (General concepts only)	High	No	No	No

Scratch	Global Kids Coding	Constructionist "Sandbox" (Project building)	No	Very High	No	Yes	Yes
Duolingo	Global Language Learning	Gamified, bite-sized exercises	No (CEFR standards)	Medium	Yes	Yes	Yes
Eureka (Proposed)	Egypt High School & University	Interactive gamified questions with spaced repetition	Yes	High	Yes	Teacher made exams, exercises and interactive lessons	Yes

Chapter 3

System Requirements

Functional Requirements

Authentication & User Management

FR1. Users shall be able to register and log in as either teachers or students using email or third-party authentication.
FR2. Users shall be able to update basic profile information such as name and picture.
FR3. Users shall be able to log out of the system.
FR4. Users shall be able to reset their password through email.

Student Learning Features

FR5. Students shall be able to view lesson explanations in text, audio, video, or mixed formats.
FR6. Students shall be able to chat with an AI bot while studying lesson explanations.
FR7. Students shall be able to practice exercises for each lesson.
FR8. Students shall be required to pass one or more milestone questions to unlock later lessons.
FR9. Students shall be able to skip to later lessons by completing a placement quiz.
FR10. Students shall be able to track lesson completion.
FR11. Students shall be able to track mistakes over time.
FR12. Students shall be able to track review progress.
FR13. Students shall be able to search for subjects and lessons through a search bar.

Classroom Features

FR14. Students shall be able to join teacher-created classes.
FR15. Students shall be able to solve class-specific problems, study class materials, and take class exams.

FR16. Teachers shall be able to create classes.
FR17. Teachers shall be able to add or remove students from their classes.
FR18. Teachers shall be able to create learning materials, exercises, and exams using the platform's interactive templates.

FR19. Teachers shall be able to edit or delete any lesson, exercise, or exam they have created.
FR20. Teachers shall be able to preview any exercise or exam before publishing it to students.

FR21. Teachers shall be able to track student progress.
FR22. The system shall provide a decision support system (DSS) to help teachers identify weak areas and performance trends.

Teacher–Student Interaction

FR23. Students shall be able to chat directly with their teacher inside the class environment.
FR24. Students shall be able to comment on teacher-posted materials.
FR25. Students shall be able to react to teacher-posted materials using simple reactions (e.g., like, check, question mark).
FR26. Teachers shall be able to moderate or remove comments in their class.

Interactive Content & Learning Mechanics

FR27. All self-learning questions shall be interactive.
FR28. The platform shall utilize spaced repetition to improve memory retention.
FR29. The platform shall provide three review queues: a global queue, a subject-level queue, and a lesson-level queue.
FR30. The platform shall add class questions and exam questions into review queues if the student opts in.
FR31. Review times shall be adaptive based on student performance.
FR32. Questions shall be automatically moved within the review queues based on performance.

Gamification & Motivation

FR33. The system shall provide experience points, levels, and progress indicators to motivate students.
FR34. The system shall award achievements or badges for key milestones (mastery, completion, reviews).
FR35. The system shall avoid streak-based pressure and keep gamification balanced and non-addictive.
FR36. The system shall display visual mastery progression for each topic.

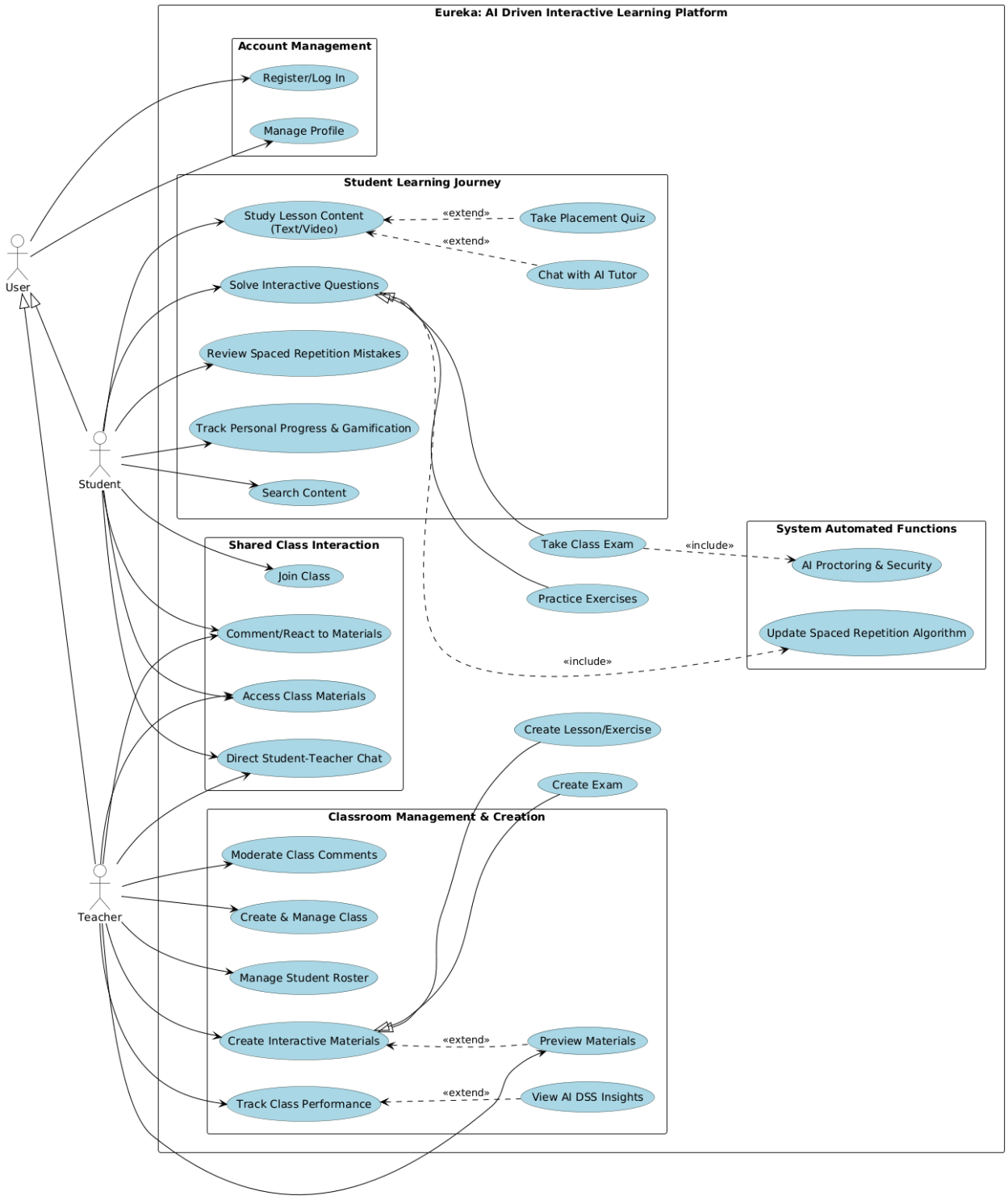
Notification System

FR37. The system shall notify students when they have pending spaced-repetition reviews.
FR38. The system shall notify students when teachers post new class materials, assignments, or exams.
FR39. The system shall notify students of upcoming exams or deadlines.
FR40. The system shall notify teachers about student submissions, class activity, and performance alerts.

Exam System & Proctoring

FR41. The system shall randomize question order during exams.
FR42. The system shall provide a locked full-screen exam mode.
FR43. The system shall prevent tab switching or opening new windows during exams.
FR44. The system shall support the following exam question types: MCQ, essay, interactive, and interactive-essay.
FR45. The system shall automatically submit the exam when time expires.

Use Case Diagram



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