

Project Sketch

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Software Project 3

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# Initial Situation

An increasing number of children are encountering difficulties in learning mathematics, presenting significant challenges for both parents and teachers [1]. Additionally, there is a growing number of parents who want their children to attend prestigious universities, aiming to ensure that their children receive a high-quality education. While online solutions for teaching children mathematics exist, they often offer only a limited range of exercise types and lack the flexibility to effectively help children improve their skills in mathematics on an individual basis. Furthermore, digitalisation is driving a transition from traditional paper-based learning methods to digital alternatives, such as tablets. Schools are seeking online solutions to replace their traditional teaching methods; however, the solutions currently available on the market do not fulfil the demands schools have.

Commentary by Pascal:

* Referring to Chapter 4, where we conduct an in-depth analysis of competitors
* Sources will be identified for the technical report to the meet the requirements of our Language Professor, indicating that further research is necessary.

# Idea

Mathify, a mathematics quiz specifically designed for primary school students from grades one to six, aims to tackle two significant challenges: First, the difficulties many children face with mathematics, which often persist throughout their lives; and second, the growing need for early support to secure a promising future for children. Through playful learning, Mathify enables students to enhance their mathematical skills and prepare specifically for exams. The customer benefit lies in the improvement of mathematical competence and the motivation of children to engage with mathematics, providing parents and educators with an effective tool to support children's early development in a fun and engaging way.

Commentary by Pascal to key word difficulties:

Challenges faced by primary grade students in mathematics and our app’s solutions:

1. **Primary grade students often encounter difficulties in grasping the concept of numbers and their values, which complicates their ability to perform basic calculations.**  
     
   --> To address this, our app starts with basic exercises using the number line, such as identifying larger numbers and sequencing numbers correctly.  
     
   Open question: Do we want to visualize a number line?
2. **Basic mathematical operations – addition, subtraction, multiplication, and division – present challenges, particularly for 1st grade to 3rd grade students.**   
     
   --> Our app introduces these concepts progressively, starting with numbers 1 to 5 and extending up to 1000. Initially, exercises utilize the number line, gradually progressing to written problems.
3. **Math anxiety, fuelled by fear of errors, negative experiences, or external pressures, can significantly impact a student’s performance.**   
     
   --> Our app aims to mitigate this by encouraging students with motivational slogans like “You are still great! Just try again”. Additionally, we offer recognition through badges for effort, regardless of the correctness of answers (e.g. a badge for “hard work”).  
     
   Open question: Does everybody agree that this would make sense? We could put this into a post-MVP release.

Commentary by Pascal to key word playful learning:

Ensuring playful learning in a math quiz involves incorporating elements that make the experience engaging and fun for students. This approach can help reduce math anxiety, enhance motivation, and improve learning outcomes. Here are strategies how we want to create a playful learning environment in our math quiz:

1. Gamification: We will introduce game elements such as points, levels, and leaderboards. Primary students earn points for correct answers, level up after mastering a set of skills, and see their progress on a leaderboard, encouraging a healthy competitive spirit.  
   Open question:
   1. **Determining the number of questions per level:**  
      My Proposal: Moderate number of questions, such as 10 per level, can maintain interest without overwhelming the student.   
      --> 100 points, 10 for right answer, 5 for wrong answer
   2. **Stuck on a level until reaching a certain point threshold? Do we offer additional help or hints after repeated failed attempts?**   
      My Proposal: Implementing a points threshold to progress level (e.g. 8/10) to motivate students to master the content before moving on. Implementation of hints depend on complexity.  
      --> Post-MVP
   3. **Encouraging students after each answer through gamification?**  
      My proposal: positive feedback for right answers (e.g. "Well done!”), constructive feedback (e.g. “You are still doing great! Just try again!”) for wrong attempts! Moreover, partial points for effort, emphasizing learning over correctness.  
      MVP
   4. **Implementing a badge system:**  
      My proposal: Offering a variety of badges for different achievements (e.g. perfect score, streaks of correct answers, or mastering specific topics)  
      --> Post-MVP

# Benefits of the Client

In this chapter, a deeper exploration is undertaken into the customer benefits of the mathematics quiz application, Mathify, for primary school students. The application offers a unique blend of education and entertainment, specifically aimed at improving children's mathematical abilities through playful learning. The following are the key advantages that will convince customers – parents, teachers, and students themselves – to choose the product:

## Improvement of Mathematical Skills

Through targeted exercises and quiz questions that align with the curriculum (German: Lehrplan), students can deepen their mathematical knowledge. The application adapts to the learning progress, offers individually tailored challenges, and thus helps to effectively close knowledge gaps.

Commentary by Pascal:

The basis for the math quiz is provided by the national syllabus of Switzerland called Lehrplan 21. The Lehrplan 21 is a common curriculum for the compulsory schools in the German-speaking cantons of Switzerland. It aims to harmonize education across Switzerland, facilitating student mobility between cantons and ensuring a consistently high quality of education.

## Motivation Boost

The playful design of the application and the integration of reward elements, such as badges and point systems, motivates children to engage with mathematics. This boosts not only their performance but also their confidence in the subject.

## Early Support

The application enables early support of mathematical abilities, which is crucial for providing children with a solid foundation for their further academic and professional career. Early developed mathematical competencies are a key to academic success and a promising future.

## Flexibility and Convenience

Parents and teachers can utilise the application as a flexible learning tool available anytime and anywhere. It adapts to the children's scheduling constraints and individual pace, thereby improving the efficiency of the learning process.

## Exam Preparation

Through targeted exam preparation and the opportunity to practice specific subject areas, the application offers students a significant advantage. This enhances their confidence and contributes to better results in mathematics exams.

## New Opportunities for Teaching

For teachers, the application opens new possibilities for mathematics instruction. It serves as a supplementary tool to make lessons more interactive and to allow students more differentiated learning.

Through these advantages, Mathify addresses not only the immediate needs of students to improve their mathematical skills but also provides parents and teachers an effective tool for supporting and nurturing children. The combination of playful learning, individual adaptation, and a focus on exam preparation makes Mathify a valuable resource in the educational path of the children.

# State of the Art / Competition Analysis

Multiple solutions already exist on the market for online learning. The most well-known is Khan Academy, a non-profit educational organisation, which provides a broad range of exercises ranging from kindergarten to college level. Khan Academy teaches mathematical concepts through online videos. However, relying heavily on videos to teach mathematical topics leads to diminishing engagement among children, resulting in a decreased interest in the learning process. Additionally, Khan Academy lacks a feature that allows children to create a mock exam by selecting specific topics for them to practice. Consequently, each relevant topic must be practiced separately, and multiple exercise types cannot be practiced at the same time. [2]

Mathify employs a playful approach to teach children essential mathematical concepts. Rather than passively watching a video, children will be guided through an engaging story illustrating the application of mathematical rules. Additionally, Mathify enables the creation of mock exams tailored to their needs by selecting specific mathematical topics. These exams serve as valuable tools for both children and teachers.

Commentary by Pascal:

Open question: Should we (and if so, how) guide primary students through an engaging story?

My proposal: We could introduce each topic in a playful manner (e.g. “No worries [Player Name]! Let’s start with something simple - [Subject Name]!

Another solution is Prodigy, an educational platform that employs a role-playing game format to teach children concepts of mathematics through quests and challenges, which the player must solve. Prodigy operates on a freemium model, where certain premium features are locked, prompting the player to upgrade to the premium subscription. Furthermore, Prodigy’s playful gameplay provides limited customisation as content is predetermined and cannot be customised to tailor to the user’s needs. [3]

In contrast, Mathify distinguishes itself from platforms like Prodigy by offering a flexible monthly subscription model that ensures uninterrupted access to its full range of features. Unlike Prodigy, Mathify provides a rich variety of dynamically generated exercises tailored to individual, allowing children to continuously enhance their mathematical skills. With Mathify, users benefit from a user-friendly interface, personalized learning paths, and the ability to track progress over time, making it an ideal choice for both students and teachers seeking an effective and engaging math learning experience.

Commentary by Pascal:

Ideas for a Subscription Model:

1. **Basic Subscription: “Math Explorer”**
   1. Features: Basic set of exercises, no customization, no leaderboards, no badges
   2. Content Updates: No monthly updates
   3. Support: No access to online help
   4. Price for 1 login: CHF 1.- / month or CHF 10.- / year
2. **Premium Subscription: “Math Adventure”**
   1. Features: All exercise types and modus, leaderboards, saving of scores, badges, mascot, etc.
   2. Content Updates: Monthly updates with new quizzes and challenges
   3. Support: Access to online help and FAQs
   4. Price for 1 login: CHF 5.- / month or CHF 50 / year  
      --> free trial period of 1 month to encourage sign-ups
3. **School Edition: “Math Champions”**
   1. Features: Multi-user licenses for classroom use, including all “Math Adventure” features
   2. Professional Development: Resources and webinars for teachers on integrating the app into their curriculum effectively
   3. Customization: Ability to customize content to align with classroom needs. Moreover, automatic or tailored mock exams can be created by the teacher.
   4. Content Updates: Monthly updates with new materials designed to complement classroom learning
   5. Support: Online support plus an additional technical support for the initial setup and explanation in school
   6. School Engagement: Special contests and challenges to promote healthy competition among classes or schools
   7. Price: Annual subscription fee based on the number of students (CHF 30.- / year / student --> Minimally CHF 600.- / year ), with a free 1-month-demo and pilot period.

# Context Scenario

## Motivation, Trigger

The number of children encountering difficulties in grasping fundamental concepts of mathematics is increasing [1]. Simultaneously, parents want their children to attend prestigious universities, driving the demand for an online learning platform that teaches children the concepts of mathematics.

## Persona and their Goals

Lea is eight years old and in the second grade. In her spare time, she likes to study, but only if it contains playful elements. She struggles to keep up with her mathematics lectures at school, finding them dull. However, Lea is eager to improve her mathematics skills, provided that her learning experience is playful and interactive.

Matthias is 46 years old and has been teaching mathematics to students ranging from fourth to sixth grade for the last 15 years. To prepare his students for upcoming exams, he creates mock exams by hand, which consumes a lot of his time. Particularly during exam season, he does not have enough time to create mock exams tailored to every class. Consequently, his students face challenges when they want to prepare for upcoming exams. He wants to improve this process by automatically generating mock exams with different exercises for each class.

## Actions and Interactions

When the user opens the application for the first time, they are prompted to input their name and current grade. Afterwards they can select the game mode, after which the application generates randomised exercises based on the selected mode. While solving the exercises, the application computes a score based on the accuracy of their solutions, allowing the user to track their current progress.

Commentary by Pascal:

Open question: Which features should be included in the MVP?   
a) The ability to select a game mode (beginner, intermediate, advanced)?

b) Score computation and leaderboard integration?

c) Persistent saving of leaderboard data?

When a teacher enters the application, they are also prompted to input their name and the grade they currently teach. Afterwards they can create mock exams by specifying which topics the mock exams should cover and they can forward it to their students, allowing students to prepare for upcoming exams by solving the mock exams.

The application itself can be accessed anywhere a child or teacher has internet access on their device.

## Problems

Children may encounter difficulties navigating online applications if they are not familiar with them. In such cases, parents and teachers can provide support, such as assisting with logging into the application if incorrect usernames are entered.

Commentary by Pascal:

Open question: How does this exactly look like?

My proposal: Add two enhancements to our Post-MVP Feature List:

1. Providing a master access to both schools and parents, and
2. Introducing a dedicated helpline for Premium Account holders and educational institutions

# Additional Requirements

Mathify, tailored for students from grades one to six, will be designed with the flexibility to accommodate additional functionalities and scalability to meet diverse educational needs. Key features to be included beyond the MVP will encompass:

Commentary by Pascal:

In my view, we should revise our concept to encompass grades 1 to 3, considering that the national syllabus (Lehrplan 21) is divided into three cycles covering everything from grades 1 to 9. We could position our approach to cover the entirety of Lehrplan 21 but begin our MVP focusing on primary school levels 1 through 3.

## Essential requirements

* **Progress Tracking and Analytics**: In-depth performance analytics for teachers and parents, offering insights into individual and class-wide progress, helping to tailor instruction and intervention strategies.
* **Safety and Privacy Expansion**: A commitment to safety and privacy not just for the target age group but with the potential to extend these protections as the scope broadens to encompass other subjects and educational levels. The game will be developed with the infrastructure to support additional safeguards and privacy measures as needed.
* **Cantonal Education System Integration**: Recognising Switzerland's diverse educational landscape, the game will include adaptable modules that perfectly align with the unique curricula, teaching methods, and standards of each canton. This ensures the game remains relevant and effective across the entire country, facilitating a seamless integration into the local educational ecosystems.
* **Educational Range Extension**: The architecture will be designed to eventually cater to students up to the Berufsmatura level, the final schooling before university-level education. This extension will allow for continuous support of a student's educational journey, potentially including preparatory content for higher education and vocational training.

Commentary by Pascal:

It is essential for us to clearly define what constitutes the MVP and elaborate on its specifics. Additionally, I recommend omitting the section on integrating with the cantonal education system as the Lehrplan 21 harmonizes everything.

Basic Feature List for the MVP includes:

* Coverage for grades 1 to 3 of primary education
* Registration process, requiring a name and grade
* Scoreboard feature --> JSON
* Exercise generation
* Check if answer is right / wrong
* Encouraging feedback after each correct answer?

## Future Requirements

* **Engaging Game Modes:** To captivate and sustain students' interest, future iterations of the game will introduce a variety of game modes. Time Challenges and Puzzle Games are just the beginning, designed to cater to different learning styles and preferences, ensuring that every student finds a mode that resonates with their personal learning journey.

These enhancements aim to provide a comprehensive educational tool adaptable to the changing landscapes of digital learning and educational standards.

The same applies to future enhancements. We should map out our planned enhancements on a timeline to give our stakeholders a clear visual representation of what’s to come:

Planned Features for Post-MPV:

* Expanding Modes: Introducing Mixed, Challenge, Custom, and Mock Exam Modes
* Database Persistence
* Enhanced Security Measures
* Expansion of exercises to grades 4-9
* Master access for educators and parents
* Subscription model with different features
* Dedicated helpline support
* Mascot: Adding a fun, engaging character to our platform
* School challenges: Encouraging competition and engagement within and between schools
* Global & local leaderboards: Showcasing achievements on both a global and local scale.
* ...

# Resources

For the development and project management a team of five IT students have been selected.

## Members and skills

* Micha Mettler: Java, TypeScript Angular, REST, Git
* Rafael Gonçalves: Java, Git
* Jonas Zehnder: Java, REST, Git
* Ragavan Thayananthan: Java, Git
* Pascal Küng: Java, Git

## Important future skills and expertise

* Advanced knowledge of mathematic Java libraries (for higher grades)
* Database management in a full stack application (with PostgreSQL)
* Deployment on a Swiss web hosting
* UI/UX for frontend
* Marketing via external marketing agency

## Estimate of expenses

1. **Software Licensing:**
   1. a. **IDE (Integrated Development Environment):**
      1. Utilising school licenses for development environments like IntelliJ IDEA or Eclipse to manage costs.
   2. **GitHub Enterprise:**
      1. Utilising school licenses for GitHub Enterprise to facilitate version control and collaborative development.
2. **Hardware:**
   1. **Notebooks:**
      1. Utilising private notebooks owned by team members for development work. Confirming that each team member has access to a suitable computing environment.
3. **Working Hours:**
   1. As students, the project benefits from the commitment of the team members, contributing their working hours towards development and project management. It is crucial to track and value the time spent on the project to understand resource allocation and potential needs for additional support or adjustments to the timeline.
4. **Contingency:**
   1. Set aside a contingency fund for unforeseen expenses or emergent needs that may arise during the development process.

**Total Estimated Expenses:** Considering the outlined factors and the academic context, the estimated expenses for the 3-month development period range from $5,000 to $10,000, with potential adjustments based on evolving project requirements and any unanticipated challenges.

It is important to maintain flexibility in the budget, regularly reassessing the team's progress and adjusting financial allocations accordingly. Additionally, explore opportunities for cost-saving measures, such as open-source alternatives and educational licenses for software tools.

Commentary by Pascal:

I will create a financial plan should it become necessary at any stage of our project.

# Risks

The following risks have been identified:

* Tech Stack  
  One potential risk originates from the team's decision to implement Spark, a backend framework with which the team is not familiar yet. Despite Spark's appeal for its lightweight design to cut down on complexity, there is a concern that it might not include all the features needed.  
  Additionally, the team faces a potential risk as only one member is currently proficient in the frontend framework Angular. This could pose a challenge in situations of illness or unexpected absences, impacting project continuity.

Furthermore, the implementation of REST APIs is new to all team members, thereby affecting the project's certainty in the technology dimension.

* Project Scope  
  It is crucial to clearly define the project scope given that the math problems could span a wide array of topics. Consequently, there is a risk of dedicating resources to non-essential math problems while overlooking those that are vital.

Commentary by Pascal:

* We should all reconsider the risks. I can create an Excel spreadsheet listing all the risks, where we can assess them during each review.

What are potential risks of our project:

Immediate Risks:

* Technical complexity: There’s a risk of underestimating the complexity, leading to delays or subpar outcomes.
* Software bugs and glitches: These bugs and glitches could range from minor annoyances to major issues that compromise the functionality of the quiz (or later the security of user data).
* User Interface and Experience (UI/UX) Mistakes: The success of Mathify depends on its ease of use and engagement. Poor UI/UX design can lead to a frustrating user experience, reducing the effectiveness of the educational tool and potentially deterring users.
* Compliance with Educational Standards: Ensuring the content and structure of the quiz are compliant with educational standards and particularly the Lehrplan 21. After go-live, this requires constant updates and verifications. There’s a risk of non-compliance, which can affect the quiz’s credibility and utility.
* Project Management and Communication: Effective coordination and communication with our team are crucial. Mismanagement can lead to misunderstandings, overlooked requirements and missed deadlines, impacting the success of Mathify.

Post-MVP Risks:

* Scalability concerns: As the user base grows, the quiz application needs to handle increased loads without performance degradation. Failing to design for scalability from the outset can lead to significant rework and optimization efforts later.
* Data Security and Privacy: Handling user data requires rigorous attention to security and privacy. Any oversight in this area can lead to data breaches, compromising user trust and potentially even violating laws.
* Subscription: Need to find a trusted partner and negotiate a competitive fee share deal  
  (Beta-Release is for free – as often seen in app development)
* Cross-Platform Compatibility: The quiz needs to function seamlessly across various devices and operating systems. Neglecting cross-platform compatibility can limit accessibility and diminish the user experience.
* Dependency Management: We rely on external libraries and frameworks. There’s a risk associated with these dependencies, including security vulnerabilities, license issues, and the potential for these dependencies to become unsupported or obsolete.

# Planning

To gather early user feedback and validate project estimations, this initial beta release is scheduled for completion within a 12-week period, divided into six sprints. Each sprint will focus on developing specific functionalities outlined in the Use Cases, with the first five sprints dedicated to achieving a Minimum Viable Product (MVP).  
The MVP will introduce the Story Mode, as part of Use Case 3 (UC3), offering core features essential for learning basic math problems. The Mixed, Challenge, and Custom modes are also categorised within UC3 but will not be developed for the initial MVP. These modes, while valuable for enhancing the learning experience and providing varied challenges, will be considered for future development cycles post-MVP.  
The sixth and final sprint, known as the Innovation sprint, will be reserved for potential inclusion of the Mixed Mode if time permits, and for implementing general technical improvements based on early feedback. It is important to note that the Challenge and Custom modes, as well as the exercise creation feature described in UC4, will not be included in the beta release. The aim is to focus on delivering a solid and reliable Story Mode in the MVP to establish a solid foundation for the platform.

The following Use Cases have been identified:

**Use Case 1 (UC1): Register Student**  
The student provides their name, class, and game mode at the beginning. Based on the entries, the exercises are generated, and the game mode is set.

**Use Case 2 (UC2): Solve Math Problems**  
The student initiates the game mode, prompting the program to generate random, grade-appropriate exercises, which vary by the selected mode. In Story Mode, an overview feature provides narrative context and tracks progress. The student solves the exercises, with the program confirming the correctness of the solutions.

**Use Case 3 (UC3): Calculate/Display Score**  
Based on the student's solution, the program calculates the student's new score and adjusts the exercises accordingly. In addition, an entry is made in the scoreboard, or the score is increased/decreased if the student's name is already registered.

**Use Case 4 (UC4): Create Exercises**  
The teacher creates exercises appropriate to the current teaching material for the class, which can then be passed on to the students. The students subsequently solve the exercises.

**Other Requirements:**

* The software architecture must be designed for easy expansion to accommodate UC4, along with any other future enhancements.
* In the beta release, no database persistence is being implemented.
* The beta release is not focusing on security requirements. However, it will be implemented in such a way that these requirements can be integrated without major changes.

## Schedule

|  |  |  |  |
| --- | --- | --- | --- |
| Sprints | | | |
| Sprint No | Date | Objectives | Notes |
| 1 | 26.02.24 – 10.03.24 | * Determine project idea * Finalise project sketch |  |
| **M1** (11.03.24) – Presentation Project Sketch | | | |
| 2 | 11.03.24 – 24.03.24 | * Finalise architecture and domain model * Setup base project and GitHub repository * Base pattern for backend logic (UC2) |  |
| 3 | 25.03.24 – 07.04.24 | * User registration, grade, and mode selection (UC1) * Score calculation and scoreboard (UC3) |  |
| 4 | 08.04.24 – 14.04.24 | * Implementation math problems grade 1-3 (UC2) * Story Mode progress overview (UC2) |  |
| **M2** (15.04.24) – Solution Design, technical Documentation I | | | |
| 5 | 15.04.24 – 28.04.24 | * Finalise Story Mode implementation (UC2) * Implementation math problems grade 4-6 (UC2) |  |
| 6 | 06.05 – 13.05.24 | * **Innovation Sprint** * Mixed Mode Implementation (UC2) |  |
| **M3** (13.05.24) – Beta-Release, technical Documentation II | | | |

To keep the documentation including its artefacts up to date is part of every sprint.

# Profitability

Mathify's economic forecast is based on strategic planning with the following assumptions:

* **Subscription Price**: CHF 5 per customer per month, aligned with industry standards for educational applications.
* **Market Size**: In Switzerland, the target market includes about 1.2 million students up to Berufsmatur level.
* **Customer Growth**: Aiming for 70,000 users within five years, leveraging the scalability of the product.
* **Labour Costs**: With a five-person team, labour costs start at CHF 60,000 per person annually, with potential adjustments as the company grows.
* **Marketing and Expansion**: Beginning with CHF 5,000 annually, there is an anticipation of an increase in marketing investment to reach a broader audience, peaking at CHF 500,000 per year as the presence solidifies.
* **Administrative Costs**: Initially minimal and later adjusted for office space and other operational needs.

## Financial Projections:

**Revenues**: Projected from user subscriptions, with additional income streams from potential partnerships and licensing deals.

**Costs**: Include fixed labour, increasing marketing spend, administrative expenses, and investment in product enhancements.

**Profitability**: Expected to turn positive in year three, with significant growth as the service expands and matures.

A comprehensive financial table will be developed, depicting revenue, costs, and profit over the five-year period, following the example structure. The financial model will be updated to accommodate the current team size and projected operational changes, maintaining a conservative yet positive outlook on growth and profitability.

# List of Figures

[1] *6 Out of 10 Children and Adolescents Are Not Learning a Minimum in Reading and Math* [Online]. Available: https://uis.unesco.org/en/news/6-out-10-children-and-adolescents-are-not-learning-minimum-reading-and-math [Queried: 09.03.2024]

[2] *Khan Academy* [Online]. Available: https://de.khanacademy.org [Queried: 08.03.2024]

[3] *Prodigy, Make* *Math and English fun for kids* [Online]. Available: https://www.prodigygame.com/main-en [Queried: 08.03.2024]