LEXAYUDHA : AI-BASED PERSONALIZED REHABILITATION FOR DYSLEXIA AND DYSCALCULIA ADOLESCENTS

Project ID : 24-25J_233

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Project Proposal Report

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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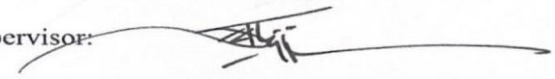
The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor:  Date: 2024/02/23

Abstract

Dyscalculia is a learning disability related to problems in the understanding and manipulation of numbers, usually leading to difficulty in acquiring basic mathematical skills. Much of the previous research in this area has been reported to be focused on teaching basic mathematical functions to dyscalculic students through various approaches, many of which rely on a single sensory modality. While this is the case, it has been shown that with multisensory teaching methods like the Touch Math method, the effectiveness of learning in students with dyscalculia increased. This had not, however, been appropriately integrated into software until recently and was only restricted to a physical environment for teaching. The current research will fill this gap by designing a web-based application for the Touch Math method to enhance number sense and mathematical operations in children with dyscalculia. This study focused on enhancing memorization skills through its gamified and multisensory learning experience and introducing a new technique for surmounting the difficulty of mathematical learning. The outcome of this research is expected to be a more user-friendly and more accessible tool to both the educator and learner and could potentially become the benchmark for strategies of intervention in dyscalculia.

***Keywords**: Dyscalculia, Touch math approach, AI-driven personalization,*

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LIST OF ABBREVIATIONS

NSMOE	Number Sense and Mathematical Operations Enhancement
SQL	Structured Querry Language

1. INTRODUCTION

Dyscalculia is a learning disability that deals explicitly with problems of learning and performing arithmetic operations. It is estimated to affect approximately 3-6% of the population[1]. In such children, there will be an impairment in understanding numbers, learning math facts, and reasoning mathematically. The impact of dyscalculia is deep and normally leads to long-lasting academic problems, affecting daily life activities in most cases because most things require basic numerical understanding.

Traditional educational interventions for dyscalculia include the single-sensory type of teaching methods. They target one of the three learning channels: visual, auditory, and kinesthetic. Research indicates that these may not be sufficient to address even the basic needs of a dyscalculic student. On the other hand, multi-sensory teaching techniques, which involve more than one sense simultaneously, have been shown in studies such as [3], and [4], to enhance drastically better learning outcomes in adolescents with dyscalculia.

One such method of multisensory approach is the Touch Math method, developed in the 1970s, which has been quite promising in improving mathematical abilities among children affected with dyscalculia. Through this method, children learn the numerical concepts by physically interacting with the numbers through tactile, visual, and auditory stimuli. Research has consistently demonstrated that Touch Math can effectively increase student engagement and retention of mathematical concepts compared to traditional teaching methods [5][6].

Although Touch Math has shown itself to be very effective, its application so far has mostly been limited to in-person teaching environments. The lack of digital platforms using this method is a tremendous gap in the current landscape of educational tools for the treatment of dyscalculia. This situation warrants much faster development of interactive, digital solutions that introduce Touch Math into classrooms and beyond.

Current technological solutions, such as adaptive learning programs and math games, have little or no multi-sensory integration. Most heal a multi-sensory impact through the use of features such as visual aid and auditory feedback, but none resembles a full multi-sensory experience such as that presented through Touch Math. Such a tool has

such potential for lasting and fun ways to learn, game-like, accessed at a distance, in order to continue with education outside of customary classroom environments.

The purpose of this study is to establish a web-based application of the Touch Math approach and thereby set a limitation on the existing digital educational tools for dyscalculia. Utilizing the principles from multisensory learning in enhancing number sense and mathematical operations in children with dyscalculia, the proposed solution is expected to achieve such objectives. It is expected that, through the study, Touch Math will be effectively transformed into a digital format that will offer the community an available and usable tool, therefore promoting school efficiency for students with dyscalculia from around the globe.

1.1 Background

Recently, much of the technology integration into education has been channeled toward addressing the unique learning needs of neurodiverse populations, which includes people with specific learning disabilities such as dyscalculia. Dyscalculia is one of the learning disabilities that encompasses serious difficulties in understanding numbers, learning math facts, and performing arithmetic operations. This learning disability affects as many as 3-6% of the population and is related to long-term academic difficulties and everyday activities that require only basic numerical insights. Despite its effectiveness, the application of the Touch Math approach in digital platforms remains limited. With the growing digitization of educational environments, an urgent need is created for developing digital, interactive solutions to bring the benefits of Touch Math into the online learning environment. From here, proper interactive digital solutions should be drawn up to provide scalable and accessible tools applicable to classroom and remote learning situations to allow the dyscalculic students the benefit of an uninterrupted education.

1.2 Literature Survey

While ingenious in most cases, existing digital tools for dyscalculic learners lack a fully integrated multisensory experience. However, a few notable attempts show the adaptability of the Touch Math approach to online platforms.

Touch Math Pro is a digitized online platform version of traditional Touch Math. This provides educators and students with a rich set of tools for developing mathematical skills through multisensory learning. It has an interactive set of exercises that can potentially make the understanding of numbers and arithmetic operations more concrete with a familiar touch-point method. The numbers will appear with corresponding touch points, which will give the students a better mental picture of the numerical values and their relationships. On top of that, Touch Math Pro integrates progress-tracing capabilities designed to measure students' performance over time and give educators an accounting of student progress to identify areas of additional help.

Touch Math Tutor Kindergarten Demo is an innovative, engaging digital system allowing young beginners to access the first resources for learning mathematics under the Touch Math methodology. The software features an entertaining character called UnoBear, who guides the students through an interesting sequence of multisensory activities aimed at strengthening the understanding of number concepts. These activities include Touching/Counting Patterns, understanding Number Concepts from 1 to 20, mastering Addition with sums up to 10, practicing Backward Counting from 10 and below, and performing Subtraction from 10 and below. The creative, highly engaging images keep young learners in a state of awe with the learning process and make their time spent interacting with the touch points in learning mathematical skills very productive.

While these platforms are essential first steps toward the digitization of the Touch Math approach, they are still somewhat limited in scope and functionality. The focus of both platforms is more toward early math skills, and neither really exploits much of the potential of multisensory learning especially moving into higher-order mathematical concepts into tailoring individualized learning experiences.

1.3 Research Gap

Despite the demonstrated effectiveness of the Touch Math approach in improving mathematical abilities in children with dyscalculia, significant gaps remain in the integration of this method with modern educational technology. Current digital formats, such as TouchMath Pro and TouchMath Tutor Kindergarten Demo, only provide simple translation from the traditional Touch Math exercises into digital formats. These are fewer interactive platforms that don't maximize the use of technology in providing a more engaging and transformational learning experience. For example, whereas students can view and engage with touch points on numbers, advanced features, such as real-time pronunciation feedback or adaptive learning pathways, to cite a few examples, would really boost learning outcomes in a way that corresponds to individual students' progress.

Besides this, the available systems are mostly not dynamic and lack interactivity to hold the interest of the student. This restricted interactivity may lead to low motivation and therefore reduce the retention since the student feels less challenged and inadequately supported by the tools. This idea of individualizing learning for students with dyscalculia is quite great; however, the majority of online platforms in place work with the 'one-size-fits-all' approach. What is not factored in is the individualization of each student's learning pace and style; this can, in turn, accentuate the problems of a student with dyscalculia.

One critical area that has not been considered before is the use of speech recognition technology integrated into the Touch Math approach. No existing digital platform provides for a student to pronounce the numbers using touch points and on the spot, show whether it is correct or not. This feature would be important in the strengthening of number sense and mathematical operations because when the children see and feel the numbers, it makes them also correctly verbalize. Students would correct their pronunciation in time and proceed to do advanced tasks only when the basic tasks are well mastered, ensuring key ideas are comprehensively understood.
More importantly, that there is a general lack of learning centers that envision a complete multi-sensory learning approach stresses the need for the development of learning facilities for those people with Dyscalculia. The present work attempts to

bridge this gap by developing a web-based application that not only adopts the basic principles of the Touch Math approach but also further amplifies it through the use of newly introduced advanced technology features. By ensuring that the design provided for a more interactive and individualized learning process, it is expected that this will improve the educational performances of the dyscalculic student and eventually narrow the gap between traditional versus digital learning.

Table 1: System Comparison

	Touch Math Pro	Touch Math Tutor	Nanashilpa	LexAyudha
Use the Touch Math approach	Yes	Yes	No	Yes
Technology Integration	Yes	Yes	Yes	Yes
Personalized activities	No	No	Yes	Yes
User attractive interfaces (multi scenery)	No	No	Yes	Yes
Voice recognition techniques	No	No	Yes	Yes
Teaching process	No	No	Yes	Yes
Provide activities to improve the math concepts.	Yes	Yes	Yes	Yes

1.4 Research Problem

For children with dyscalculia, major cognitive difficulties are involved in the course of learning mathematical skills; traditional educational methods that make a heavy use of rote memorization and single-sensory techniques of teaching are not able to effectively help such children. These traditional methods do not usually develop basic analytical skills for understanding and manipulation of mathematical operations, hence the continual mathematical difficulties throughout a student's academic life into adulthood.

Traditional teaching methods are very inadequate, especially due to their inability to adapt and accommodate learner needs. Children with dyscalculia need even more individualization of educational approaches, taking into consideration unique features of each cognitive profile. The effect of this deficient practice in providing personal learning experiences has greatly limited the potential of children with dyscalculia to meaningfully engage with mathematical concepts, usually leading to disengagement, frustration, and perpetual academic difficulties.

Given these challenges, there is a dire need to have other methods that better meet the special learning needs of children with dyscalculia. Much promise lies with the Touch Math method because it uses the multisensory method of teaching mathematics. This method puts a lot of hope into making mathematical concepts more accessible to children with learning disabilities by engaging the visual, auditory, and tactile senses for clearer understanding and retention of mathematical information.

And though it has worked, the application of the Touch Math method has been a bit more contained in the physical teaching environment as opposed to the digital or technologically augmented platforms. This is a gap in today's solutions for education. The advantages that would follow from, for example, overlaying the Touch Math method on today's modern technology, especially with the use of machine learning and natural language processing for an interactive digital overlay, would be significant. These technologies would support the creation of increasingly personal and more interactive learning experiences: students' real-time feedback, interaction with mathematical content in a way that suits their learning needs.

The study will investigate the effectiveness of the Touch Math approach and find different ways in which it could be further improved with technology integration. In particular, it will be concentrated on developing a web-based platform that will include not only the just-mentioned bare basics of Touch Math but also machine learning and NLP in this learning environment to make it more tailored, adaptive, and interactive. This will enhance students' mathematical understanding and their analytic skills in facing challenges throughout traditional approaches toward education and hence achieving greater academic success for students with dyscalculia.

2. OBJECTIVES

2.1 Main Objective

The overall objective of the present research study is to design, develop, and validate a novel AI-driven web-based platform tailored to meet reading skills enhancement needs of students with dyslexia and dyscalculia. This shall make use of state-of-the-art technologies such as Artificial Intelligence, Chromatic Variation Techniques, and Natural Language Processing in providing a very personalized and adaptive learning environment. It solves advanced challenges of dyslexia, especially in reading fluency, reading comprehension, and visual stress, by providing a dynamic educational tool that is able to adapt in real time according to the needs of each student. And on the other side, provide students who have dyscalculia with a tool to help them overcome their math-based problems through tried methodologies in the medical sciences. Further, through exploiting the usability of emotion detections and speech pace, the tool ensures friendliness of the system to the users, hence stress free. This will offer the necessary support that will help students suffering from dyslexia and dyscalculia achieve better academic performances and overall learning achievements than if they had used other methods, by being more supportive, effective, and engaging in student education.

2.2 Sub Objectives

1. Development of Personalized Learning Paths for Dyscalculic Adolescents: Design an adaptive diagnostic assessment tool that is in a position to handily and correctly express the difficulty areas of number sense and mathematical operations for each dyscalculic student. This assessment will enable the creation of personal learning paths in the platform so that the most basic problem areas for each student are covered. The entire learning process will become more effective because the platform will tailor

the learning material according to the needs of the learner, providing a personalized learning experience for every student.

2. Implementation of the Touch Math Approach for Teaching Number Sense:

Formulate a structured teaching module using the Touch Math approach: Introduce numbers through interactive touch points. This module will help students progress, step by step, from a very basic number concept to more difficult number sense. The teaching process will be followed by practice sessions where students count the touch points on the shown numbers. It will harness the latest NLP technologies in analyzing the correctness of student pronunciations in real time. Correct pronunciations will mean progression to subsequent lessons, and wrong attempts will trigger immediate corrective feedback and support.

3. Design of Interactive Practice Sessions for Reinforcing Number Sense:

Design a set of interactive workouts in which students themselves mark the touch points in numbers. This activity is aimed at strengthening the learning of number concepts by the students and at the same time providing instant and formatively feedback to them. Student progress will be monitored, and the platform at runtime itself will adapt the difficulty of tasks so that each student stays challenged, yet not overwhelmed by that, hence leading to steady and sustainable learning growth.

4. Enhancement of Mathematical Operations Through Visual and Interactive Techniques:

Create a comprehensive instructional module dedicated to teaching basic mathematical operations, combining the Touch Math approach with advanced visualization tools. This session will use visual aids, interactive elements, and step-by-step instructions to help students intuitively understand and apply mathematical topics. Following the lecture, students will participate in exercises designed to reinforce these operations. Throughout practice sessions, the platform will provide contextual clues and guidance, assisting students in overcoming problems and achieving mastery of mathematical processes.

5. Integration of Real-Time Feedback Mechanisms and Adaptive Learning Strategies:

Embed real-time feedback systems in the platform so that students get immediate and actionable responses to their efforts in pronunciation exercises, touch point activities, and solving mathematical problems as soon as they interact. The platform shall continuously analyze student performance data for modifying the next tasks in terms of complexity and content, hence personalizing the learning experience, making it engaging, and responsive to the evolution of each student's needs.

6. Pilot Testing and Iterative Refinement of the Platform:

Conduct extensive pilot testing with a selected group of dyscalculic teenagers to establish proof of the effectiveness of the platform on enhancing number sense and mathematical operations. This will provide both quantitative and qualitative data, with metrics on learning outcomes, user satisfaction, and usability. Putting into practice lessons learned from the pilot, refines the platform further to the best standard of educational effectiveness and usability before its broader implementation.

3. METHODOLOGY

The proposed system, LexAyudha, will offer a personalized, adaptive learning experience to adolescents suffering from dyslexia. To this end, LexAyudha builds upon state-of-the-art technologies like deep learning, natural language processing, and cloud computing to provide a very responsive and efficient user experience. At the core of LexAyudha is a robust microservice framework-based architecture that enables seamless integration of heterogeneous technological components with scalability and enhanced security. Every single component of the system has been designed to work together in a cohesive form, enabling the delivery of customized educational content suited to its users' unique needs.

Figure 1 gives the overall system architecture, elaborating on how different modules play with each other to provide a seamless learning environment. In this, there are four core components targeted at one aspect of the learning process in the system: LexAyudha. Though diagrammatically shown as a single server, for performance, fault tolerance, continuous integration, and deployment purposes, the server will be implemented using microservices. The use of MongoDB Atlas will work efficiently with data to scale without losing reliability and speed. The system backend is deployed on Render. The containerization has been done using Docker while orchestration has been done by Kubernetes. A front-end web application on Vercel will complement the setup, allowing users to interface seamlessly and responsively. This pairing of technologies ensures that LexAyudha does more than just meet the performance expectations placed on it today but is also future proof in that respect.

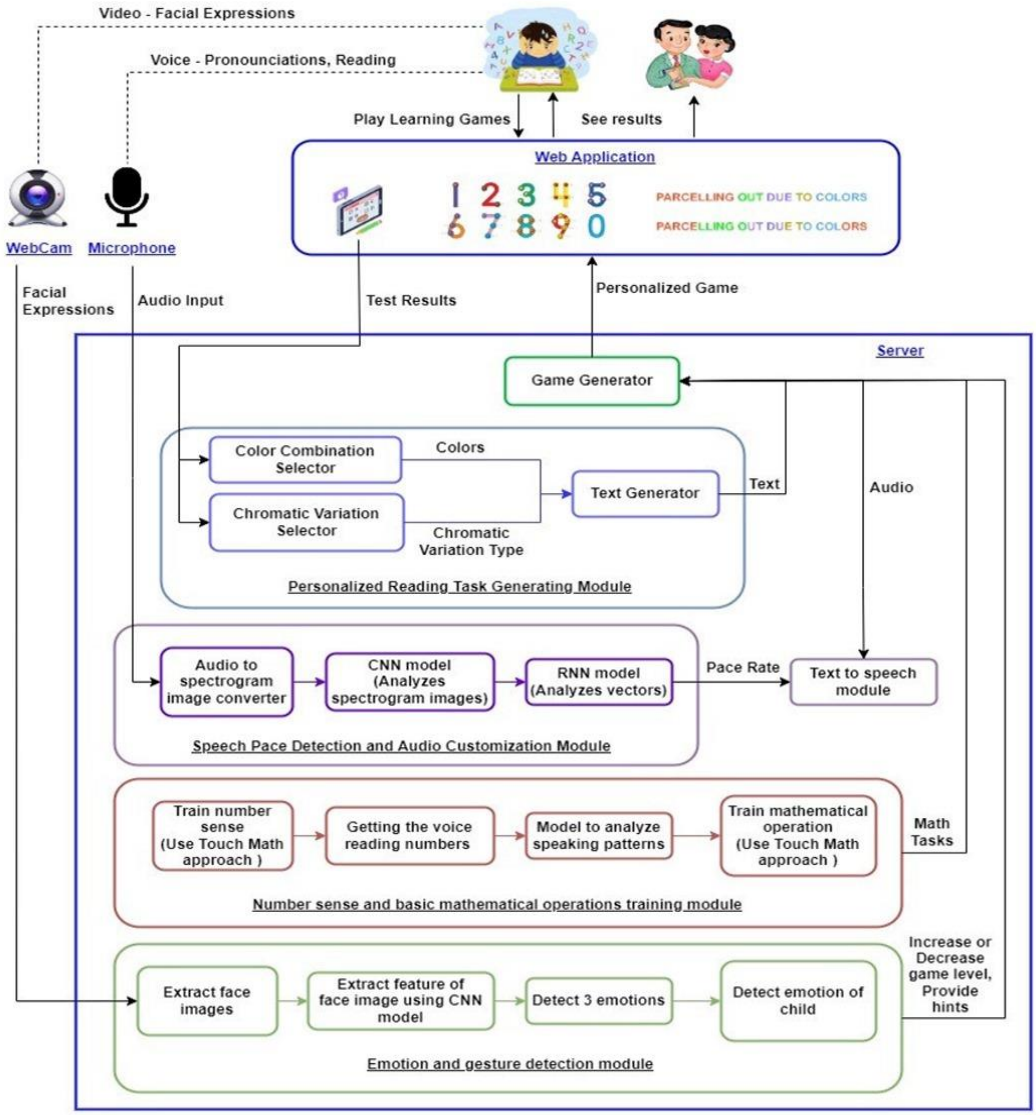

Figure 1: Lexayudha System Overview Diagram

The methodology adopted for the development of this AI-driven web-based platform to improve reading skills for dyslexic students is Agile Software Development Life Cycle. Agile has been chosen for the purpose of this project due to its iteration and flexibility for continuous feedback, rapid prototyping, and on-going refinement—a methodologies approach very well-suited for a project requiring constant adaptation to user needs and technological advancement, as specified in Appendix B.

As shown in Figure 2, the following overall system use case diagram captures the high-level system requirements.

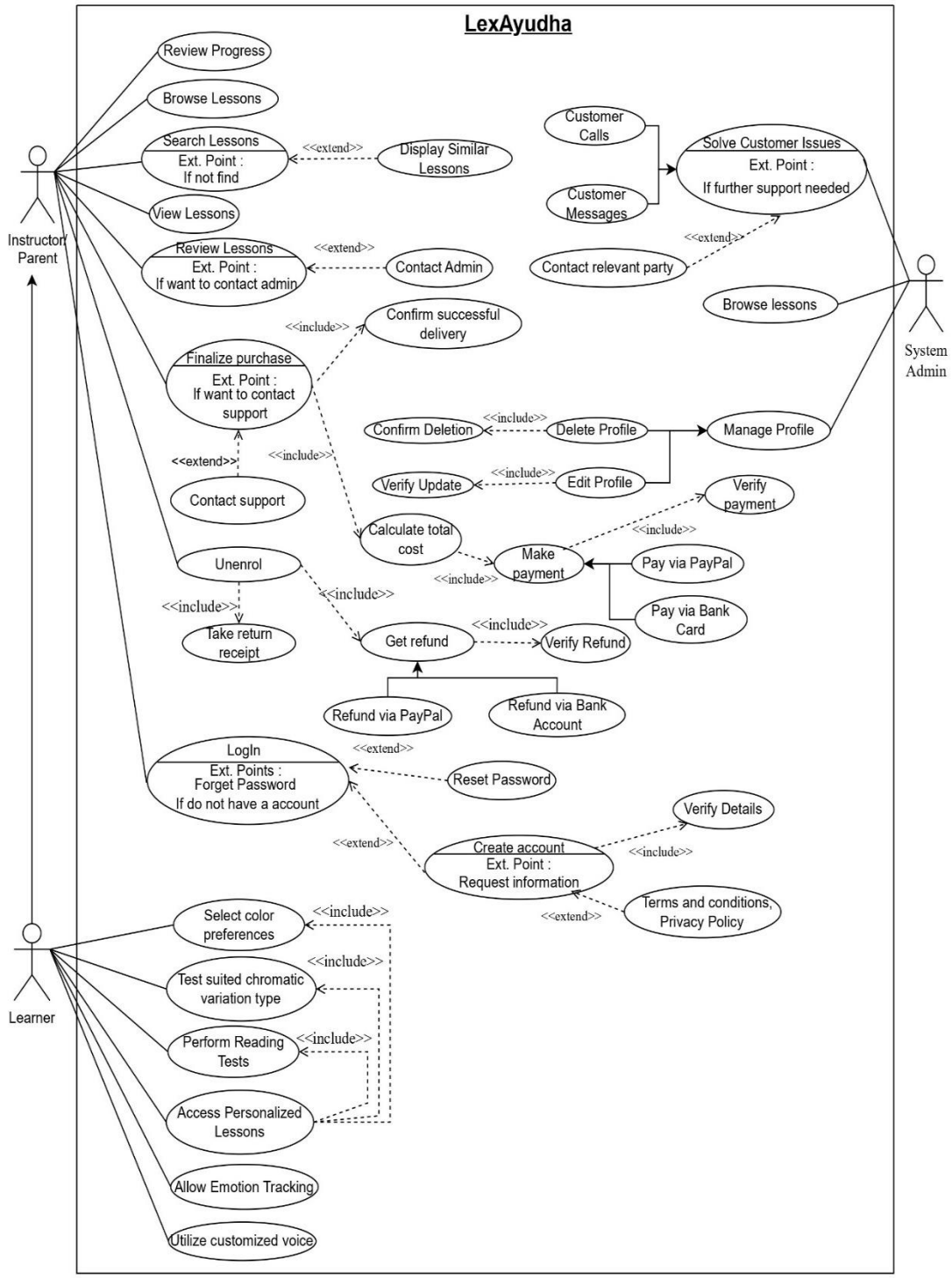

Figure 2: System Use Case Diagram

Apart from the common system overview, each component can also be further broken down into smaller sub-units with distinct technological layers. In this study, the

Number Sense and Mathematical Operations Enhancement (NSMOE) will be explored in greater detail. The methodology adopted for the development of this AI-driven web-based platform to improve analytical skills for dyscalculic students is the Agile Software Development Life Cycle. Agile has been chosen for this project due to its iteration and flexibility for continuous feedback, rapid prototyping, and on-going refinement a methodologies approach very well-suited for a project requiring constant adaptation to user needs and technological advancement, as specified in Appendix A. Figure 3, illustrates the sub-component distribution of the NSMOE component.

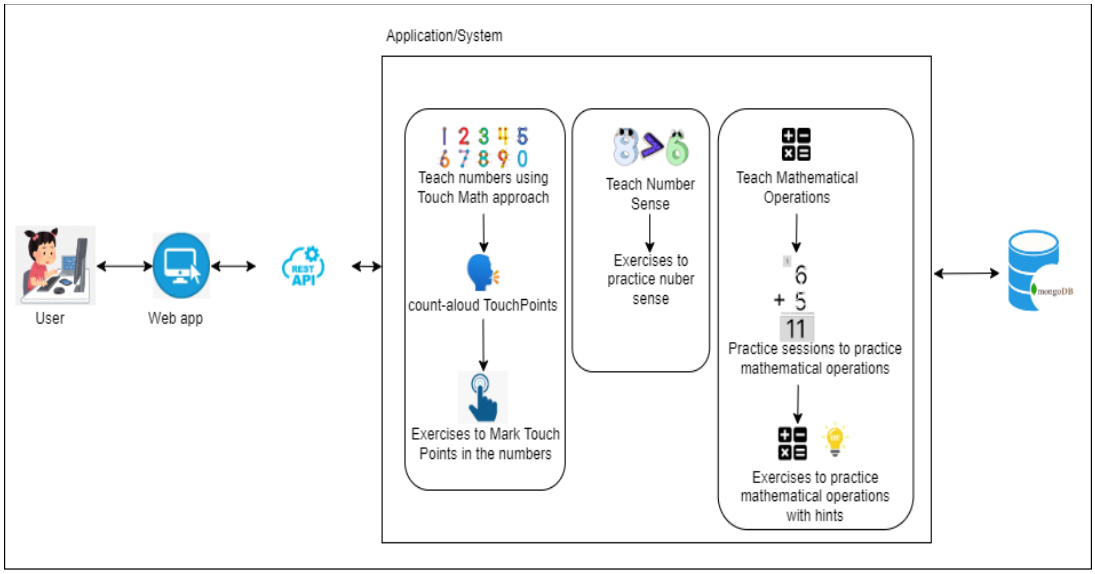

Figure 3: NSMOE System Diagram

The NSMOE component in LexAyudha attempts to improve number sense and mathematical operations in students with dyscalculia, based on the Touch Math methodology. The first phase is an in-depth diagnostic assessment of the strengths and weaknesses of each student in mathematics. This diagnostic test gives the system an indication of what areas the student needs more practice in and thus creates the learning pathway for the student accordingly.

After the assessment, the Touch Math method for the numbers will be introduced to the students. It is a multi-sensory approach where numbers are represented with touch points. The students engage with these touch points by counting them, and that helps them remember the numerical values of the numbers. In this approach, through tactual

and visual involvement, the familiarity with numbers is enhanced. In Figure 4, shows an image of a Touch Math approach.

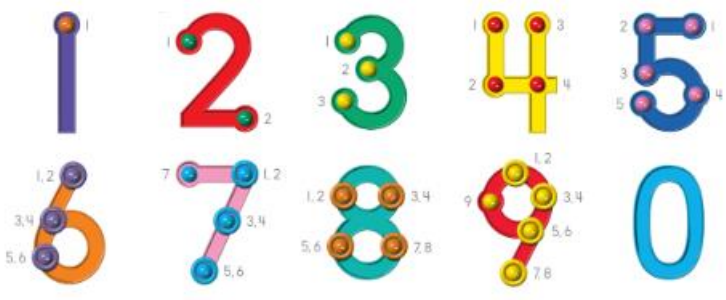

Figure 4: Visualization of touch math approach

There are follow-ups of practice sessions where the student is given numbers and asked to identify and count the touch points. The practice sessions are also meant to allow the student to repeat the practices for learning reinforcement. In these practice sessions, NLP technologies are used to evaluate whether the student pronounced it correctly. If they pronounce it correctly, then they will progress to other higher levels, therefore, ascertaining that basics are well learned before proceeding to the next.

Once students have a good foundation in numbers, the NSMOE component introduces basic arithmetic operations such as addition, subtraction, multiplication, and division. This, too, is also taught using the Touch Math method, with some other visual aids to help the students get a 'feel' for what the mathematical process is doing. Exercises are given to practice what was learned after the teaching of each session. The system continually monitors how well they are performing and offers real-time assistance when the students fall out of step to make sure that the student is able to succeed.

With this process, the NSMOE component adapts learning content based on the progress and performance of each student. This method creates a tailor-made learning experience for each student at their ease of understanding, keeping them engaged and confident. Further, all data on students' performance their number identification ability, mathematical operations, and clarity in pronunciation are logged and then persisted to the MongoDB Atlas database. This information may be very useful in refining such learning paths individually, system responses according to the needs of

each student, and assessing overall the effectiveness of the system in enhancing the mathematical ability of students.

Tools and Technologies

- **MongoDB Atlas:** For cloud-based data management.
- **Render, Docker, and Kubernetes:** For hosting, containerization, and orchestration of the server-side components.
- **Vercel:** For hosting the front-end web application.
- **NLP Technologies:** For speech-to-text conversion and pronunciation accuracy detection.
- **Touch Math Techniques:** For enhancing number sense and mathematical operations.

Anticipated Outcomes

It is envisaged that upon successful implementation, the NSMOE component of the LexAyudha system will be able to significantly improve the mathematical abilities of students with dyscalculia. It realizes these goals through a personalized interactive learning process to improve number sense, fluency in basic arithmetic operations, and confidence in mathematics. It utilizes the best of technology today, such as NLP, with the Touch Math method to drive home an effective and engaging learning experience that gives students the best opportunity for better grades.

Commercialization Aspects of the Product

It is in fact a business opportunity for the proposed AI-driven adaptive web-based platform, as it uniquely fills the gap in the education sector empowered by personalization in adaptive learning experiences for students with dyslexia. The potential number of people with dyslexia is fairly large, and interest in effective and scalable educational solutions has been quite pervasive and growing at a very fast rate. By providing a solution using artificial intelligence, chromatic variations, and natural language processing, the platform will be positioned as part of the best in class for this EdTech marketplace.

Target Market

The two target markets for this solution will primarily be schools and other educational facilities, as well as parents of dyslexic students. Key Target Audiences for these target markets include:

Primary and Secondary Schools: Public and private schools that afford special education programs have a great opportunity. These will most frequently be looking out for a package that can help teach such children with learning disabilities, and what the platform will offer in terms of personalized and adaptive learning will effectively meet this demand.

Parents: Parents of dyslexic children make another crucial segment of the market. In general, parents are more than glad to pay for materials or services which would enable their children to climb up the ladder educationally, especially if the regular learning methodologies have failed.

Educational technology companies: Suitable educational technology companies can also become collaborative to scale the reach of this platform. Many of these companies work to expand their product lines with creative solutions; in this light, the inclusion of this platform in their existing suites will be beneficial for both parties.

Dyslexia Advocacy Groups: It can form alliances with independent, non-profit making dyslexia advocacy groups dedicated to making lives with dyslexia better and echo this platform for more visibility and credibility in general.

Pricing models

This would be a flexible pricing strategy that caters to the needs and budgets of the target market in order to be successful financially. For the purpose of pricing, it may use any one of the following models:

Subscription based model:

The plan will apply a tiered subscription model at a fee charged, plus the features required. With the next tier of features being the advanced tiers, which include advance analytics and an extended library of content with further customization options, the

example of one basic tier including the core features, such as individual learning paths and chromatic adjustments. Therefore, depending on the level of service needed, the price will range from $5 and above monthly.

Freemium Model:

That is why, for instance, on this platform, a freemium model could be used where all the basic functionalities would be free of charge. Therefore, users would have experience of the platform and subsequently transfer to the paid version. By subscription, premium feature advanced AI-driven content customization, detailed progress reports, and more support options could be unlock.

Market Strategy

A market strategy will be put in place to commercialize the platform successfully .

Marketing and Outreach

Participating in educational technology related meetings and visiting places offering education for dyslexics and dyscalculics can be of importance, which will enable the creation of brand awareness. This helps to network potential clients and other stakeholders. Impressions on the potentials of the platform for benefiting students with dyslexia and dyscalculia can be achieved through the demos or presentations made at these events.

Online marketing will be conducted through digital campaigns that place ads on social media, educational forums, and search engines for both school and parent buyers. Thought leadership on this subject will be built using content marketing for those in education for whom dyslexia is a concern. Collaboration with schools and special education programs will facilitate early testing for the platform.

Dyslexia advocacy groups can boost the believability as well as exposure in the community. Support for the platform as well as ongoing development can be provided through these groups based on input.

Sales Channels

Direct Sales: Working on a face-to-face basis with schools, colleges, and school districts to make aware the platform and close contracts.

Online Sales Portal: The channel will also be purchasable and subscribable through online sales portals, thus being easily accessible to individual customers and smaller institutions.

Only high customer support will help in the retention of the user base and, thus, ensure word-of-mouth publicity. The support services will consist of onboarding assistance, training sessions for educators, and continuous technical support.

Regular updates and improvements, based on user feedback, will maintain the relevance and effectiveness of the platform and thereby secure customer satisfaction in the long term.

Global Expansion

In future, after the platform is developed for the English-speaking markets, the company will get further development of the platform, which will provide an opportunity to cover many languages and educational systems across the globe. The content and the user interface of the platform will be localized based on the specific needs of the international markets.

Revenue Projections and Long-Term Vision

This is so because, if well priced and marketed, large potential can be realized in terms of revenue generation on this platform. Most of the revenues in the first few years will come from subscription sale. Further with the growth, when the user base has increased, more ways can be figured out to better monetize the platform, such as data analytics services provided to institutions or premium content and features.

4. PERSONAL AND FACILITIES

Number sense and mathematical operations enhancements component will be planned, implemented and delivered as per the below task management plan and per the allocated timeline.

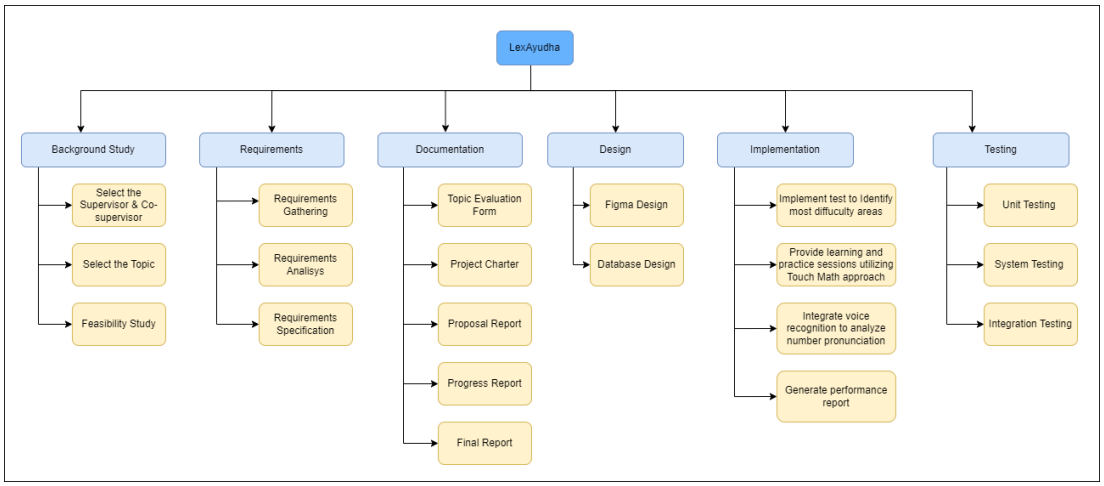

Figure 4.1: WorkBreakdown Structure

Task name	Progress	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Project Initiation																	
Study about research gaps	100%																
Deciding appropriate research area	100%																
Going through research papers	100%																
Finalizing a topic	100%																
Requirements Gathering & Analysis																	
Identifying functional requirements	100%																
Identifying non- functional requirements	100%																
Identifying data requirements	100%																
Identifying knowledge requirements	100%																
Design																	
Creating the figma prototype	100%																
Development																	
Model training	0%																
Backend Development	0%																
Frontend Development	0%																
Testing																	
Unit and API testing	0%																
Integration Testing	0%																
Load Testing	0%																
User Acceptance Testing	0%																
Deployment	0%																

Figure 4.2: Gantt Chart

5. PROJECT REQUIREMENTS

5.1 Functional Requirements

- **Teaching Numbers Using the Touch Math Approach**
    - The system shall display the numbers with touchpoints for the students to interact with.
    - These touch points must be precise, and livelier, and let the students count them by touch, hence helping the child learn the numerical value.
- **Practice Sessions for Number Sense**
    - The system will provide practice sessions for the students to identify and count the touch points on the numbers.
    - These sessions will instantly provide feedback, thus correcting the mistakes and helping in the reinforcement of learning.
- **Pronunciation Assessment**
    - The system can judge the pronunciation of the students on numbers using Natural Language Processing technology.
    - The system shall provide real-time feedback on the correctness of pronunciation, thus helping students in the articulation.
- **Teaching and Practicing Mathematical Operations**
    - The system shall contain modules for teaching the basic arithmetic operations of addition, subtraction, multiplication, and division using the Touch Math approach.
    - The system shall include practice exercises for each operation that provide immediate feedback and hints to assist the student in learning.
- **Personalized Learning Pathways**
    - The system shall automatically update the learning content based on the progress of each student and thus provide individual learning paths based on their present level of understanding.
    - The system shall offer teachers an opportunity to view and edit such designed paths when appropriate.
- **Data Collection and Performance Monitoring**

- The system is supposed to collect information about the performance of the student in number recognition, arithmetic operations, and pronunciation accuracy.
- This data is to be securely maintained in a database to conduct analysis for effective enhancement in user bespoke experience and also check how efficient the system is as a whole.

5.2 User Requirements

- **Concern to use touch points**
- **Concern about capturing speech audio data**
- **Clear voice volume**

5.3 System requirements

- **Processing power**

  The system must have enough computational power to conduct real-time audio processing and spectrogram conversion efficiently.
- **Data storage capacity**

  The system must have enough storage space to handle enormous amounts of audio files, spectrogram pictures, and speech rate data over time.
- **Scalability and load balancing**

  The system must support scalability and load balancing to manage rising user traffic and data processing demands as they arise.
- **User authentication and authorization**

  The system must include secure user authentication and authorization features to manage user access and protect sensitive data.

5.4 Non-functional Requirements

- **Accuracy of Pronunciation Assessment**

  This should be aimed at very high accuracy, less than a 5% error margin in pronunciation assessment so that the feedback is reliable, and students work to improve it.
- **Real-Time Feedback**

The system is expected to process and return the feedback on pronunciations and arithmetic exercises within 2 seconds to preserve a smooth and engaging learning experience.

- **Scalability**

  It should scale to accommodate growing student loads with no degradation in performance to ensure the same experience for all students.

- **Reliability**

  It shall ensure 99.9% uptime, hence reliable enough to provide a platform at any moment for students and teachers alike.

- **Security**

  All information about the student, personal data, and performance records, shall be encrypted both in transit and at rest.

- **Maintainability**

  The system shall be designed for maintainability, such that updating and bug-fixing and adding new features should be easy.

- **Compatibility**

  This system should work under different devices and browsers, so as students from different environments are able to access this learning platform without technical difficulties.

6. BUDGET AND BUDGET JUSTIFICATION

The proposed system was planned on a budget in a way that the cost can be reduced and hence could provide a feature rich application to the end users for an affordable price for them. Below is the planned budget for the proposed system and the budget justification. Please note that the budget allocation and the selection of the vendors can be slightly change with future findings and requirements.

Proposed Budget and allocation

Table 2.2: Proposed Budget

Description	Cost
Azure Blob Storage	$ 0.018 per GB (first 5GB free)
Azure Cosmos DB	Free tier (50 GB free for year)
AWS SageMaker	$ 0.10/hour (16 GB RAM)
Azure Virtual Machines	Free tier (750h)
Azure Speech to Text	$ 1 /hour (5 hours free per month)
AWS SES	Free (3000 emails per month)
Vercel – Frontend Deployment	Free tier
Render – Backend Deployment	Free tier

Budget justification

Azure Blob storage: Azure blob storage was chosen for it competitive pricing and the free tier. It provides $ 0.018 per GB after the free first 5GB. Blob storage has one of the lowest storage prices compared to AWS S3 bucket $ 0.023 per GB and google clouds $ 0.026 per GB. Blob Storage is well-suited due to its ease of integration, flexibility, and ability to handle unstructured data and also Azure provides a more affordable entry point while still maintaining high performance and scalability.

Azure Cosmos DB: Azure cosmos DB was selected as No SQL Database for its cost effective and extensive free tier offering 50GB of free storage per month for the first year. This makes it's the most suitable option compared to the AWS dynamodb (25 GB per month for a year) and google firestore (1 GB per month for a year). Cosmos DB also provides globally distributed, low-latency access to data, which is ideal for a real-time application like Lexayudha, where performance is critical for storing and retrieving results and feedback. Additionally, Cosmos DB supports multiple NoSQL APIs, making it flexible.

AWS SageMaker: AWS SageMaker can select as the best choice to address the machine learning parts due to its robust platform and flexible pricing options. At $0. 10/hour for an ml. t3. medium instance, SageMaker also presents a a highly cost-effective solution to running machine learning computations. It also easily interconnects with other AWS services, so this is advantageous if you decide to upscale system's AI models.

Azure Speech to Text: Azure Speech to Text was chosen for its low cost ($1/hour) and a free monthly allowance of 5 hours, which is beneficial for projects with moderate usage. Also compared to AWS and Google speech to text prices which is $1.44/hour and free 60 minutes for month, Azure speech to Text is more suitable for the system. The service's high accuracy in transcribing audio to text, along with its integration capabilities within the Azure ecosystem, makes it ideal for project's potential need for speech processing

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8. APPENDICES

Appendix A

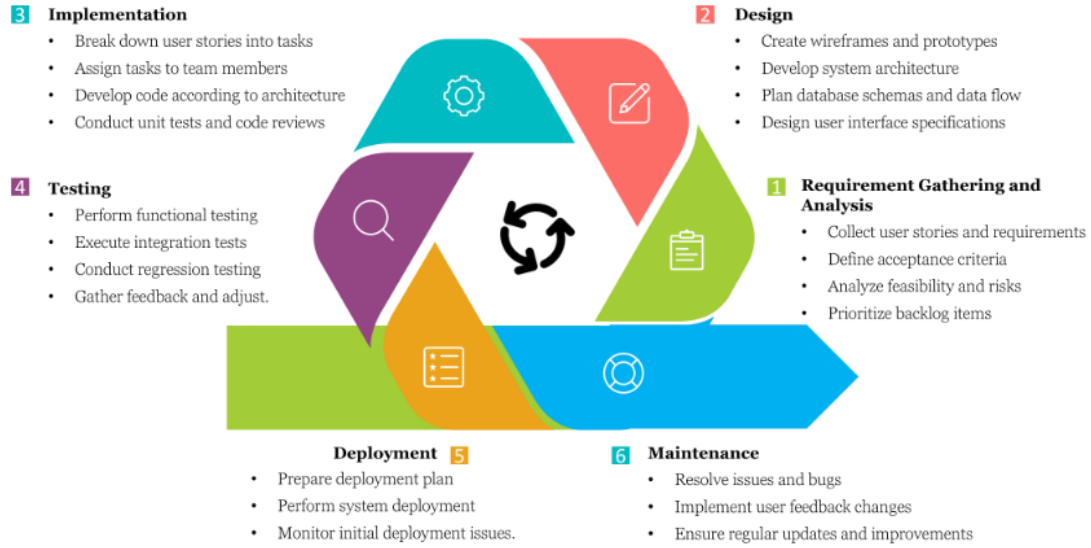

Figure 8.1: Agile Methodology