# EnlightenDS: Advanced Technologies for Skill Enhancement and Talent Recognition in Children with Down Syndrome

## Project Proposal Report

Project ID : 24-25J-228

Kumarasinghe D.P.

BSc (Hons) in Information Technology Specializing in Information Technology

Sri Lanka Institute of Information Technology
Sri Lanka

August 2024

# Project Proposal Report

Project ID: 24-25J-228

Kumarasinghe D.P. – IT21296314
Supervisor: Prof. Samantha Thelijjagoda
Co-Supervisor: Dr. Junius Anjana

BSc (Hons) in Information Technology Specializing in Information Technology

Sri Lanka Institute of Information Technology
Sri Lanka

August 2024

# 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.

| Name | Student ID | Signature |
|---|---|---|
| Kumarasinghe D.P | IT21296314 | |

The supervisor/s should certify the proposal report with the following declaration. The above candidate is carrying out research for the undergraduate dissertation under my supervision.

Signature of the supervisor
Prof.Samantha Thelijjagoda

2024/08/22
Date

Signature of the co supervisor
Dr. Junius Anjana

22/Aug/2024
Date

# ABSTRACT

EnlightenDS serves as a holistic learning platform for children with Down syndrome. It embeds an ultra-advanced assessment tool in cognitive development with Convolutional Neural Networks for the assessment of the drawings the students will make. Pre-processing of images will be done to standardize and clean the data, extracting features using a convolutional neural networks. The extracted features are matched with the developmental benchmarks of assessment of cognitive progress and give detailed feedback on whether the child's cognitive development meets, exceeds, or falls short of expected levels. Such objective assessment enables early detection of developmental concerns and facilitates timely intervention. A user-centered approach is taken into consideration when designing EnlightenDS, which incorporates the use of wireframes, flowcharts and use case diagrams. These wireframes, especially designed for checking cognitive development, making sure that it is accessible and user-friendly to both children and parents. These wireframes present images of how the cognitive assessment tools are integrated into the platform and guide a user through the process to review a student's drawing. Flowcharts offer details regarding the steps involved in sequential user interactions with the platform steps that is, to complete the cognitive assessments. Use case diagrams also focused on cognitive development assessment, views of the interaction between different user roles. It will show how each of these roles would use the assessment tools and how these interactions support the overall educational objectives of the platform by bringing these factors together in one platform, EnlightenDS gives educators and parents relevant insight into the meaningful view of student development, thereby empowering them to support each child's growth effectively.

**Keywords:** cognitive development assessment, convolutional neural networks, student drawings, artificial intelligence driven**,** wireframe, use case, flowchart

# Table of Contents

## List of Figures



## List of Tables



## List of Abbreviations

| | |
|---|---|
| Natural Language Processing | NLP |
| Convolutional neural networks | CNN |
| Down syndrome | DS |
| Artificial Intelligence | AI |
| Augmented Reality | AR |
| Test de Aprendizajey Desarrollo Infantil | TADI |
| Typically Developing | TD |

| | |
|---|---|
| User Interface | UI |

# 1. INTRODUCTION

Down syndrome, also known as trisomy 21 is a genetic condition resulting from the presence of an extra copy of chromosome 21 and it is associated with a variety of physical and intellectual disabilities. The prevalence of Down syndrome is approximately 1 in 700 births around the world, making it one of the most common genetic disorders.

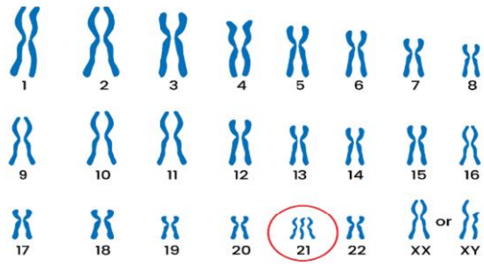


*Figure 1 -Down syndrome child chromosome image*

One of the most characteristic features of Down syndrome is a flatted facial profile and slanted eyes. A single transverse palmar crease is also a quite common physical characteristic.

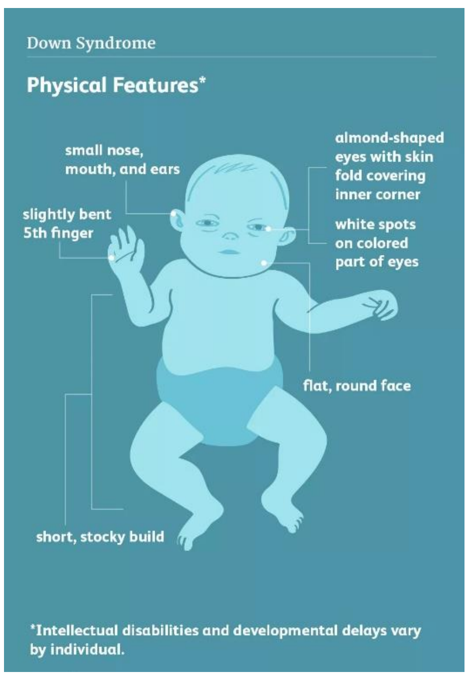


*Figure 2- Unique physical features*

Usually, individuals with Down syndrome have mild or moderate types of intellectual disability [1]. Pronunciation is one of the major difficulties that a child with Down syndrome usually faces.

It affects their enunciation and communication skills in general. Most of them require speech therapy to improve their pronunciation and enunciation abilities.

Despite all the troubles, there are usually unique strengths and hidden talents in children with Down syndrome. Many children with Down Syndrome do quite well in fields like music, drawing and graceful social relations, often exemplifying creativity and emotional intelligence. Such competencies will thrive in supportive environments that encourage self-expression and exploration. Mathematics can also be a significant challenge to those with Down syndrome. Although some have problems with numeracy and solving numerical problems, others have proven to be capable of grasping mathematical concepts when appropriately taught. The capability of knowing math can be significantly enhanced if introduced at an early age and using specific educational techniques.

Children with Down syndrome are often significantly delayed cognitively compared to same-aged peers who are developing typically. Although a child might be, for instance, 12 chronologically, their overall cognitive skills can only compare to those of a 3-year-old. In such scenarios, this vast difference influences all areas of learning, communication, and even everyday life, underscoring why a better understanding of their cognitive development is equally crucial.

This research is purposed to assist in giving directed strategies to address specific cognitive challenges and to foster the development of children, who can develop certain hidden talents like music, artistry having strong social instincts. It would therefore be possible for the caregivers and educators to ensure that children suffering from Down's syndrome have made some meaningful steps forward in terms of their cognitive development. This broad approach not only fosters cognitive enhancement but also enhances self-esteem and a sense of accomplishment.

Cognitive development knowledge of children with Down syndrome helps us to cater to and create more inclusive and supportive educational settings. With emphasis, such strengths and weaknesses can maximize the potential of these children and live a rewarding life.

Children with Down Syndrome (DS) will generally achieve the same basic motor skills necessary for everyday living and personal independence. However, it may be at a later age and with less refinement compared to those without DS [2]. Some adjusted milestones for DS are listed in the table below:

| Milestone | Range for Children with Down Syndrome | Typical Range |
|---|---|---|
| **GROSS MOTOR** | | |
| Sits Alone | 6 – 30 Months | 5 – 9 Months |
| Crawls | 8 – 22 Months | 6 – 12 Months |
| Stands | 1 – 3.25 Years | 8 – 17 Months |
| Walks Alone | 1 – 4 Years | 9 – 18 Months |
| **LANGUAGE** | | |
| First Word | 1 – 4 Years | 1 – 3 Years |
| Two-Word Phrases | 2 – 7.5 Years | 15 – 32 Months |
| **SOCIAL/SELF-HELP** | | |
| Responsive Smile | 1.5 – 5 Months | 1 – 3 Months |
| Finger Feeds | 10 – 24 Months | 7 – 14 Months |
| Drinks From Cup Unassisted | 12 – 32 Months | 9 – 17 Months |
| Uses Spoon | 13 – 39 Months | 12 – 20 Months |
| Bowel Control | 2 – 7 Years | 16 – 42 Months |
| Dresses Self Unassisted | 3.5 – 8.5 Years | 3.25 – 5 Years |

*Figure 3 -Age ranges at which children with DS are expected to achieve certain developmental skills compared to typical age ranges for children without DS*

It is common for children with DS to be delayed in reaching common milestones such as sitting independently, standing and walking.

## 1.1 Background Literature

The following literature review identifies recent research into innovative methodologies that work to enhance cognitive development in children with Down syndrome (DS). The first study investigates an augmented reality application designed with the objective of improving cognitive skills in children through interactive learning experiences. The second research paper systematically makes use of a structured questionnaire that maps on to the different stages of cognitive development that Piaget outlined and makes a systematic assessment of the cognitive challenges a child with DS may face. A retrospective study explores motor skills at different ages and their relation to cognitive/language development, in that physical development is important for the outcome regarding cognitive development. It is in this context that a study evaluating the effectiveness of early stimulation programs in Santiago, Chile, uses both developmental assessments and interactive games to check the cognitive progress of children with DS. On this basis, this cluster of research studies puts forward different ways in which cognitive development in this population may be understood and facilitated by highlighting interventions that are specifically targeted and educationally innovative.

**Augmented Reality for Cognitive Development in Down Syndrome** [3] study was done with the objective of enhancing cognitive development in Down syndrome children using an innovative Augmented Reality application. Qualitative data was gathered by conducting interviews with parents of children with DS to understand exactly the cognitive challenges that children with DS suffered from, as well as their preferences on learning tools. This was followed by a detailed literature review on the existing strategies of cognitive development and the role of AR in education. After getting insight from the literature review, the researchers designed and developed a mobile application that would use AR technology to help learn through interactive 3D objects. This allowed the user to direct the camera of their smartphone toward a marker located on the ground, and it would then display color-rich multicolored 3D objects that represented different items thus, color learning and object identification were both taught in a highly playful manner. It was tested on a sample of children and parents from the POTADS community of Indonesia for cultural relevance and access. Flowcharts to show the application's functionality and user interaction process were drawn, and a pre-quiz was conducted before and after children used the app to determine their cognitive skills and measure its effectiveness in learning outcomes.

**Improving Cognitive Assessments in Toddlers and Children with Down Syndrome Using Stealth Assessment** [4] consisted of children with DS from various early stimulation programs in Santiago. There was a total sample of 68 children, whose ages ranged from 20 to 146 months. The average time children were exposed to complementary therapies was 64.27 months. Neurological pathologies in addition to DS, prior diagnosis of autism, and complex medical treatments were exclusion criteria. Assessments took place during two structured one-hour sessions, conducted in the lab, ensuring a safe and controlled context that helps relax the participant. The main assessment tools are the Test de Aprendizaje y Desarrollo Infantil (TADI), designed for the measurement and evaluation of developed landmarks, and a set of tablet games (BENDI) developed uniquely for the project. Ethical approval was obtained before the study, and informed consent was acquired from all participating families in relation to the ethical provision of information. They also provided the evaluation personnel with special training in order to make the information obtained sensitive and accurate, considering the children's level of intellectual and developmental disability. The anonymity of the participants was maintained, and the feedback on child development was given to the families. It was followed by descriptive statistics for summarizing findings and reliability assessments to approve the instruments used in the statistical analyses, which would be used to ensure that the research outcomes are robust.

**Motor and cognitive development of children with Down syndrome** [5] was a retrospective follow-up study at the Yokohama Rehabilitation Center in Japan. The study aimed to show the relationship between motor skills and cognitive/language development among children with DS. The study included 156 children, 93 boys, and 63 girls, who attended health checkups with rehabilitation services from April 2013 to March 2017. All children in the study had been examined with the KSPD before their 48-month birthday. As a matter of fact, it has been pointed out that most participants were of multiple assessments, with 83 tested once, 57 twice, and 16 three times. The age range at the first test started at 10 to 43 months, and the mean age was at 25.3 months. Such would present a large range to examine the developmental paths. The authors conducted multiple regression analyses in order to establish whether walking skills act as a facilitator to cognitions and language development. By its nature, this design provided the opportunity for a fine-grained inspection of physical development impacts on cognitive outcomes, with implications for the child's rehabilitation program [6].

**Cognitive Impairments in Children with Down Syndrome** [7] is a cross-sectional observational study was conducted within the Department of Developmental Pediatrics and the Department of Occupational Therapy, Lahore, with a focus area of children with DS regarding cognitive development within the age group of 5 to 18 years. A structured questionnaire based on Piaget's stages of cognitive development has been applied to provide an opportunity for the systematic assessment of cognitive impairments among 30 selected children (15 males and 15 females). The sampling method was non-random and purposive in nature and targeted the children who had a diagnosis of DS while ruling out the existence of other comorbid conditions that might be a confounding factor for the estimation of the cognitive function. Participants were assessed by a multidisciplinary team comprised of an occupational therapist, pediatrician, and psychologist in order to enable thorough assessment. The research team took all the required ethical permissions and collaborated with the caregivers and teachers for easy data collection. The Statistical Package for the Social Sciences was used to analyze the data, and the results were reported through pie charts to present the distributions of demographics and bar charts to illustrate significant areas of cognitive impairment. This research has helped in understanding the cognitive challenges of children with DS and proved that targeted intervention strategies are necessary for this special child population.

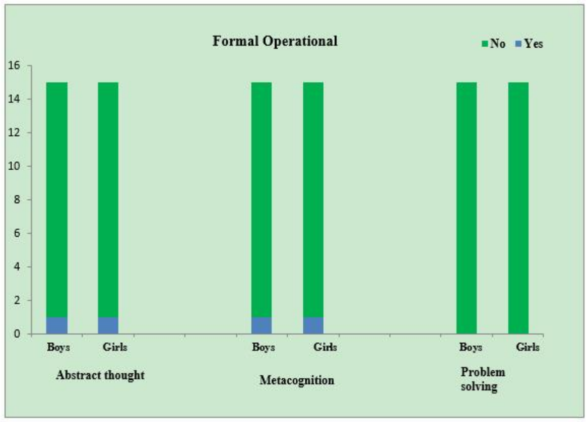


*Figure 4 -Frequency of lag in formal-operational stage*

## 1.2 Research Gap

| Features | [2] | [3] | [4] | [5] | EnlightenDS |
|---|---|---|---|---|---|
| Used a test to assess the cognitive development | ✗ | ✗ | ✗ | ✓ | ✓ |
| Used image processing | ✗ | ✗ | ✗ | ✗ | ✓ |
| Used Convolutional Neural Networks (CNN) | ✗ | ✗ | ✗ | ✗ | ✓ |
| Used Web Based Application | ✗ | ✗ | ✗ | ✗ | ✓ |
| Gender not biased | ✗ | ✓ | ✓ | ✓ | ✓ |

*Table 1- Research gap*

The research [3] focuses on the role of promoting educational tools in developing cognitive skills, with the paramount exploitation of Augmented Reality for color recognition among stalked children with Down syndrome. It's a way of engaging children with a learning modality that can be interactive but at the same time visually stimulating. Though the study makes some valuable contributions to the exploration of the potential of AR, it fails to apply powerful cognitive assessment tools that include standardized tests or metrics to comprehensively measure improvements in cognitive abilities. Although the primary focus of the study is on measuring user acceptance and knowledge acquisition, which no doubt is very important, yet it lacks a structured and scientifically validated approach towards assessing the outcomes on the cognitive development of the user. Without these more rigorously measured assessment tools, it is very challenging to quantify actual cognitive benefits that the AR interventions may provide.

The application of markerless AR as an engaging educational tool is novel in and of itself in this study. However, it doesn't include more advanced things like image processing or Convolutional Neural Networks (CNNs) in the case that possibly may unleash the potential of making the process of learning much more individual for children with Down syndrome. So, the system could analyze his peculiarities of interaction and adjust relevant responses to educational content to support his special needs in learning. It is expected, therefore, that in case such advanced techniques were not employed, then a key omission in the available body of knowledge would be existent. The tools would have the potential to increase the impact of educational intervention founded on augmented reality by being more responsive to individual differences in the cognitive development of children having Down syndrome.

Even though user acceptance is realized in the research, there is a very important element that is not put into consideration: ensuring that educational tools are free from any gender bias. Making tools equally effective for both boys and girls with Down syndrome is very important, as needs and learning styles highly vary in diverse children. It is important to design and test equally for gender neutrality in order to prevent the intervention tools from automatically being beneficial to advantage a single gender, hence causing unequal results in other genders. Indeed it is a concern that this issue has not been well addressed in the existing studies, including this one, and hence, this may not have been well noticed. One of the possible major implications of such a situation is that the results of the interventions would be relatively less effective for one gender, continuing to perpetuate the gender inequities in cognitive development.

The other major weakness in the study is that the study was only constrained to using the game applications and delivering this educational game through mobile-based applications. While mobile applications are certainly invaluable for portability and accessibility, in this study there is no exploration of the potential benefits of web-based applications. Web based applications would appreciably increase access, as this tool would be available for use by multiple children in multiple settings, using multiple devices, an enhancement for even wider access to enable children. This eventually reduces the scaling of the mobile application, as a web-based platform would under normal circumstances reach more populations, among them those who might not have access to types of mobile devices. Therefore, in the study, an overreliance on tools that are strictly mobile based only reduces the generalizability of findings and interventions, supposedly pointing to a gap in the provision of such universally accessed learning platforms for children with Down syndrome.

Adding to the list of troubles, the very focus of the study on color recognition, primarily for the purpose of cognitive enhancement, is too narrow. Cognitive development in children with Down syndrome, to begin with, is a vast domain of development that consists of problem-solving skills, memory, attention, executive functioning and many other parameters. Of course, color recognition is one major domain of cognitive development, although it is one of the subdomains out of a large domain of development. Its narrow focus only on color recognition makes it lose sight of other important aspects of development in the cognitive arena, and hence its effect and interventions appear quite limited. At the same time, the research, by concentrating only on color recognition, may lose sight of other opportunities for developing equally crucial core cognitive skills without which children with Down syndrome will never get to develop fully.

In sharp contrast to some of the unavoidable limitations of past and present research, it is proposed to address these gaps in EnlightenDS. It involves enhanced features and technologies that use the newest developments in image processing techniques with the aid of convolutional neural networks, which will provide a precise cognitive ability assessment. This to help the system analyze children's drawing and other visual input, allowing for a much finer-grained evaluation of developmental progress. By doing so, EnlightenDS provides a more nuanced and sophisticated assessment that goes beyond what traditional methods can offer. Furthermore, the system's web-based application ensures wide accessibility, making it usable in diverse settings and by a broader audience, thus overcoming the limitations of mobile-only tools. This approach makes EnlightenDS both more scalable and more inclusive of children and educators working in varied settings where mobile devices might not be widely used.

Finally, EnlightenDS was designed to ensure that gender bias did not exist in any of the assessment tools so that, in any case, the tools of the instrument would be as fair as possible for any child. This focus on gender neutrality is important in the development of educational tools that cater to the different needs of children with Down syndrome, to ensure no group is inadvertently disadvantaged. By including these advanced features, EnlightenDS offers a more accurate, inclusive, and accessible solution compared to the limitations identified in previous research.

In contrast, the new stealth assessment methods proposed in research [4] truly raise the bar for cognitive assessment. The shortcomings of this running research are that it has not used advanced technologies like image processing and CNN that are fast getting recognized as a must-have tool for modern nuanced cognitive assessment. Such technologies could realize cognitive development even more by making sense of a wide array of data, catching on visual patterns, and behavioral cues passed. No such technologies are used in the carried-out research [4] and basically the cognitive development depth cannot be fully grasped, especially for children with Down syndrome, as cognitive abilities may vary greatly.

The study does not state the web-based application that the research is lacking to provide. This helps in the field of environment in making cognitive assessment tools available and usable for the larger percentage of them in society. It is a deep concern that web-based platforms that cognitive assessment tools be of reach to very many people, including the remotest and underserved areas where mobile or special applications are not included. A missing aspect, however, is a web-based one, which can make the research findings widespread to the public and users in general since not everyone will find time to come into a lab to take the test. Another flaw in the statement would be that the possibility of gender bias in the insinuated tests is not put across. This leaves a lot of readers thinking on such an aspect of inclusivity and fairness, among others. If a study does not attend to gender bias, then such a study finding could wrongly be generalized upon some phenomena or a certain difference in cognitive development between the genders goes unnoticed. These are the current limitations that EnlightenDS is being developed to overcome by implementing the use of CNNs to provide a more advanced and fine-grained assessment of cognition. The use of CNNs helps to extract detailed features of cognitive abilities that might be missed with the help of traditional methodologies. Moreover, it opens up the access to its web-based platform from different settings, thus allowing the various users who have no favorable location or access to any special device to use the tool. In addition, EnlightenDS takes corrective measures to avoid gender biases so that the assessments are fair for all the users, regardless of gender. This way, EnlightenDS becomes a much more appropriate and fairer assessment tool in the evaluation of cognitive development among children with Down's syndrome.

Traditional assessment techniques, based on standardized cognitive and motor tests performed at fixed diagnostic intervals, are the mainstay of the research [5]. Those methods have formed the bedrock of research into cognitive development for many years and, in themselves, offer very useful insights into developmental patterns. However, they are also subject to some important limitations. Rather, these traditional assessments offer only a snapshot in time with respect to a child's development and are generally only available from clinical environments. Consequently, they are not well-suited for the continuous, real-time monitoring of cognitive development nowadays recognized as key for providing timely and effective interventions. Additionally, the methodologies used in the research [5] are not available to parents and dementia carers other than in clinical environments; thus, their use in tracking development, particularly outside a clinical setting, would be limited.

On the contrary, EnlightenDS nurtures innovative methods with the help of the latest cognitive assessments and the real-time data processing brought about by machine learning. All this enables the constant modification of an intervention and dynamic personalized assessment, accessible to parents and caretakers in real time, independent of the clinical setting. By aligning with machine learning algorithms, EnlightenDS becomes agile and adaptable to tailor the system to the requirements of each child, offering an extremely individualized approach to cognitive development. The importance of real-time adaptivity cannot be overemphasized when responding to individual differences and changing needs among the group of individuals with Down syndrome. Some may need support of various kinds at different times in their development.

The research [7] underlines different imperative issues on cognitive development, focusing on gender differences and cognitive impairments. According to the study conducted, which was premised on the Piaget theory of cognitive development, there are no major disparities on gender with regard to cognitive impairments. However, girls have been seen to exhibit more significant disabilities during the preoperational stage of development. Such findings are relevant as they underline the necessity of a gender-oriented approach in researching cognitive development. It finds a limitation in terms of sample size, which was small, and in the fact that it was of a cross-sectional design with only two institutions being involved, thereby generally limiting generalizability. The small sample size and limited scope may preclude representativeness of findings within the wider population of children with Down syndrome, which will mean a limitation in the applicability of results.

EnlightenDS was developed for this purpose: to go beyond the limitations of traditional methods of cognitive assessment and intervention with its more dynamic, individual approach. Unlike conventional static approaches followed in research study techniques [7], EnlightenDS incorporates advanced technologies like image processing and real-time feedback to be able to deliver cognitive training in a tailored manner according to every child. This enables the approach to always be responsive, with changes in the administrative and effective approaches, unlike the static assessments used in earlier studies. This offers a comprehensive and flexible package that transcends the limitations of sample size and institutional focuses for interventions involving cognitive deficiencies among children with Down syndrome, making the intervention more effective and reaching more breadth in support.

In conclusion, while the existing research gives valuable insights into the cognitive development of Down syndrome children, at the same time, it reveals several significant constraints that have to be coped with. EnlightenDS reduces the number of tools typically used in an assessment by incorporating advanced technologies such as Convolutional Neural Networks, real-time data processing and machine learning algorithms so it is the right choice in assisting with the cognitive development of children with Down syndrome. By addressing accessibility issues, gender bias and the limitations of traditional assessment methods, EnlightenDS provides a more comprehensive and effective approach to cognitive development in realizing potential among children, regardless of gender or location.

## 1.3 Research Problem

Infants and children with Down syndrome (DS) can look forward toward bright futures, as individuals with DS are living healthier, more productive lives than ever due to medical advances, opportunities for early and continued intervention, and inclusive education. Despite these advances, infants and children with DS experience challenges in specific domains of cognitive functioning relative to their typically developing (TD) peers. Over the long term, individuals with DS are also more likely to develop Alzheimer's disease relative to the general population. Understanding cognitive functioning early in life may be important in charting cognitive decline over time [8]. Most children with Down syndrome have some level of intellectual disability, usually in the mild to moderate range. People with mild intellectual disability are usually able to learn how to do everyday things like read, hold a job, and take public transportation on their own. People with moderate intellectual disability usually need more support [9].

In the present study, an effort is made to enlighten the cognitive levels of children with Down syndrome by evaluating and suggesting their cognitive development with respect to chronological age. For instance, a child with Down syndrome who may be 5 years old chronologically will substantially portray the cognitive abilities of a younger child for instance, a cognitive age of 3 or 4 years. This difference in cognitive age, as compared to chronological age, brings out the peculiarity of the developmental trajectory of children with Down syndrome, which may differ much from one child to another.

Understanding these cognitive levels more precisely would allow us to work toward tailoring interventions and educational strategies much more precisely for the needs of the individual child. It also highlights the importance of early and continuing assessment, which may go a long way in pointing out potential weaknesses that may require special attention and planning for later life when the chances of developing Alzheimer's disease are very high. This study thus aims to ultimately add to the existing knowledge of how cognitive skills develop in a child with Down syndrome. In this respect, this research would be helpful in guiding effective interventions to help enhance the quality of life and independence potential among children with the condition.

# 2. OBJECTIVES

## 2.1 Main objective

The overall system aims to create a comprehensive developmental support system for children with Down syndrome that focuses on assessing cognitive levels, improving pronunciation skills, enhancing mathematical abilities and identifying and nurturing artistic talents. This system will also provide individualized guidance to the parents and educators and develop effective metrics to assess the effectiveness of these interventions. The goal is to holistically support each child's unique potential and foster their growth in multiple domains, ensuring they achieve their fullest capabilities.

The specific objective within this system is to understand the variable cognitive development of children with Down syndrome, looking at the unique strengths and weaknesses of each child in areas such as language, memory, adaptive behavior, and social skills. Such an objective, if attained, will be helpful in tailoring educational strategies and interventions suitable to support the special developmental trajectory and potential of each child.

## 2.2 Sub objectives

- **Gather a diverse dataset of Drawings from children with Down syndrome.**
  Get a diverse collection of children's drawings with Down syndrome in order to show various stages of cognitive development.

- **Apply preprocessing techniques to prepare drawings for analysis.**
  Preprocessing is essential to prepare the raw drawings for effective analysis by the CNN such as resizing, noise reduction and normalization are applied to standardize the images. Proper preprocessing also enhances the model in focusing only on relevant features within a particular drawing which helps in the retrieval of the correct features and their assessment.

- **Utilize convolutional neural networks to extract key features from the drawings.**
  It means that CNNs then have to be used to automatically extract essential features from these pre-processed drawings. It will feed the images through multiple layers of filters that detect edges, shapes, textures, and other relevant patterns.

- **Train CNN using labeled data based on standardized scoring criteria.**

  It uses a dataset of drawings that have been labeled according to standardized cognitive development scoring criteria as the input for training a CNN model. These labels provide a reference for the CNN to learn how different features in the drawings correspond to different levels of cognitive development. Through that CNN will be capable of reliably assessing new drawings.

# 3. METHODOLOGY

## 3.1 System Architecture Diagram

### 3.1.1 Overall System Architecture Diagram

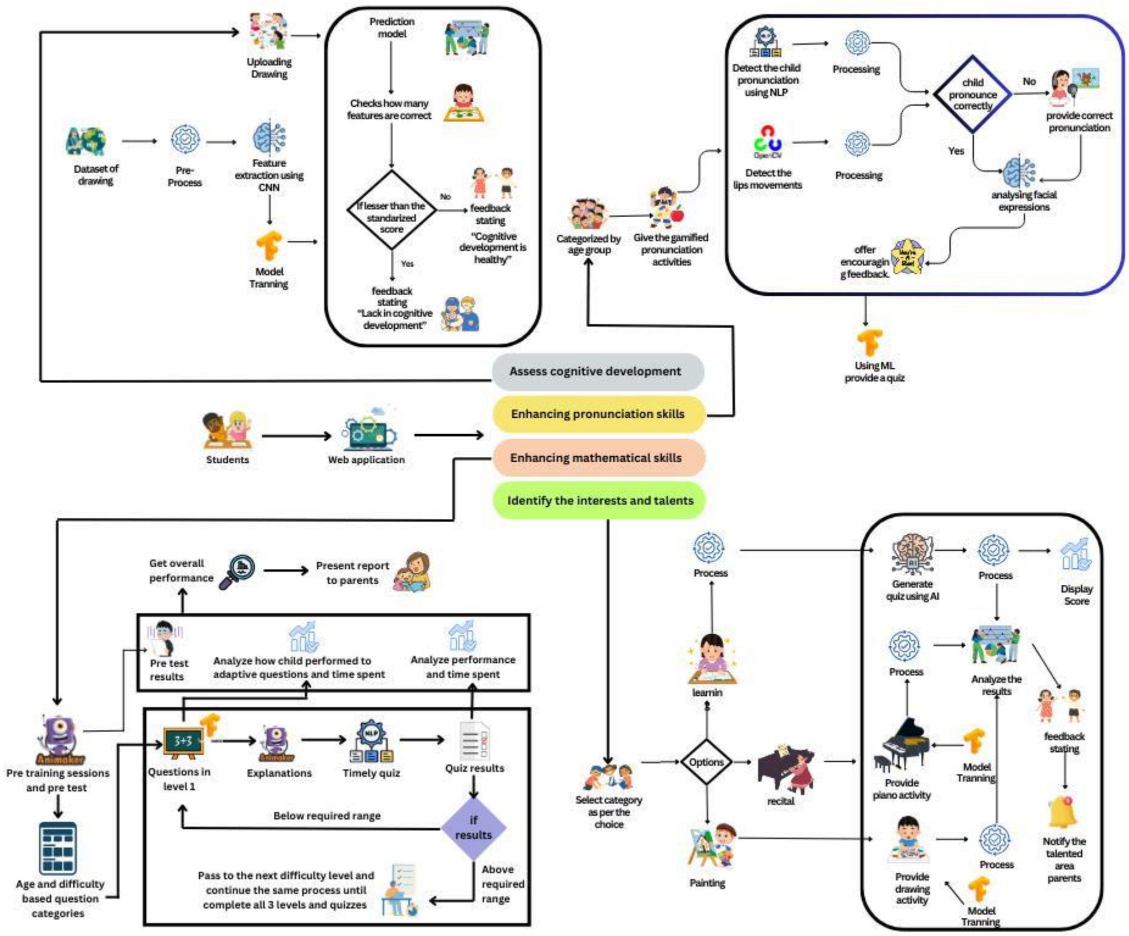

*Figure 5- Overall system diagram*

The system diagram presented outlines a sophisticated framework aimed at assessing and enhancing various aspects of children development, including cognitive abilities, pronunciation skills, mathematical proficiency and the identification of interests and talents. This framework is divided into four primary components, each playing a crucial role in the holistic development of students.

The first component focuses on **cognitive development assessment**. The process begins by gathering a dataset of student drawings, which are then pre-processed and analyzed using Convolutional Neural Networks (CNNs) to extract relevant features. These features are fed into a prediction model that evaluates the student’s cognitive development by comparing the extracted features against a standardized benchmark. If the features meet or exceed the benchmark, the system provides feedback indicating that the student’s cognitive development is healthy. On the other hand, if the features fall short, the system suggests a potential lack of cognitive development. This component effectively utilizes machine learning to provide a data-driven, objective assessment of cognitive abilities, leveraging students’ creative outputs to gauge their developmental progress.

The second component is dedicated to **enhancing pronunciation skills**. In this component, Natural Language Processing (NLP) is used to assess the accuracy of a student’s pronunciation. The system begins by analyzing the student’s speech and detecting their lip movements. If the student mispronounces a word, the system offers the correct pronunciation along with encouraging feedback, while also analyzing the student's facial expressions to understand their response. This interactive learning process is further enhanced by categorizing students according to their age group and providing gamified pronunciation activities tailored to their developmental level. This approach ensures that learning is both engaging and effective, helping students improve their language skills in an interactive, supportive environment.

The third component addresses **enhancing mathematical skills** through an adaptive learning process. Students start by taking a pre-test, which is designed to assess their current level of mathematical proficiency. Based on the pre-test results, the system guides students through a series of progressively challenging questions and quizzes, offering explanations for any mistakes made. The system adjusts the difficulty level as the student progresses, ensuring a personalized learning experience that matches the student’s pace. If a student performs well, they advance to the next level; if not, they receive additional training before retaking the quiz. This iterative process ensures that students thoroughly master each concept before moving on to more advanced topics, thereby strengthening their mathematical foundations.

The fourth component is focused on **identifying interests and talents**. In this part of the system, students can choose from a variety of activities such as learning, recital, painting, or piano playing. The system uses artificial intelligence to generate quizzes related to these activities and processes the results to analyze the student’s performance. Based on this analysis, the system provides feedback to both students and parents, highlighting areas of talent or suggesting further activities to nurture specific skills. The component's Artificial Intelligence (AI) driven model is continually refined to improve the accuracy of talent identification, ensuring that students are guided toward activities that align with their natural abilities and interests.

Overall, the system integrates these four components into a unified web application that students interact with. This integrated approach provides a comprehensive view of each student’s development, covering cognitive, linguistic, mathematical and personal growth. The data collected across these components is synthesized into a detailed report, which is then presented to the parents. This report offers valuable insights into the student's strengths and areas for improvement, enabling parents and educators to tailor educational strategies to the individual needs of the student. In essence, the system is designed to offer a holistic and personalized educational experience, leveraging advanced technologies to support the diverse aspects of student development.

### 3.1.2 Component specific system architecture diagram

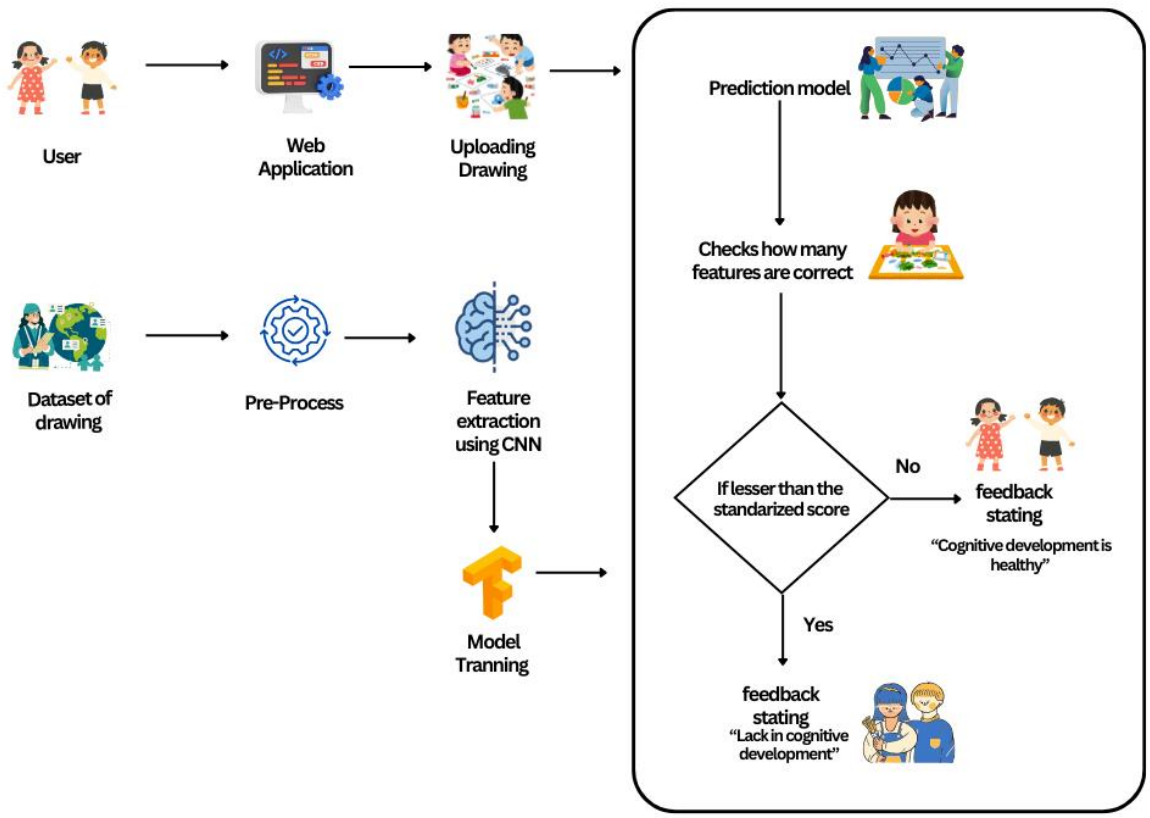


*Figure 6- Component specific system architecture diagram*

This component of the system diagram focuses on evaluating cognitive development in children through a machine learning-based approach. Basically, it starts when a user uploads the drawing through a web application. This drawing shall be part of a dataset, which already will have been pre-processed in readiness for analysis. This is an important preprocessing step since it cleans the data, resizes images, and normalizes features so that the machine learning model gets a correct interpretation of the drawings.

After pre-processing, this drawing is fed into a Convolutional Neural Network (CNN) for feature extraction. The intention behind using CNNs is that they are good at identifying and learning many patterns, shapes, and features from an image. From the drawing, the model learns these features to train a predictive model developed and polished from a large database of drawings, which capture a broad spectrum of cognitive developmental stages.

It scores the drawing by comparing the extracted features against a standardized score, set up during the model training phase. In other words, this will allow for checking how well the drawing corresponds to the indicators of cognitive development typical for the child's age group. If the number of correct or expected features in the drawing is less than the standardized score, then the system feedback is that there is a "Lack in cognitive development." This will mean that the child may not hit expected cognitive milestones with respect to his/her age and will require further evaluation or intervention.

On the other hand, if the drawing passes the standardized score, it gives positive feedback that says, "Cognitive development is healthy." It reaffirms to the parents and educators that the child is on the right developmental track. The module assumes the role of an early diagnostic tool by applying objective data from the children's drawings to provide insights into their cognitive development. The feedback generated helps in the identification of the potential areas of concern in a child early enough, allowing timely interventions that may help in supporting the child's needs in development. This is where artificial intelligence and educational psychology are combined in a nuanced, informed way to assess cognitive development in a non-invasive yet engaging manner.

### 3.1.3 Flow Chart

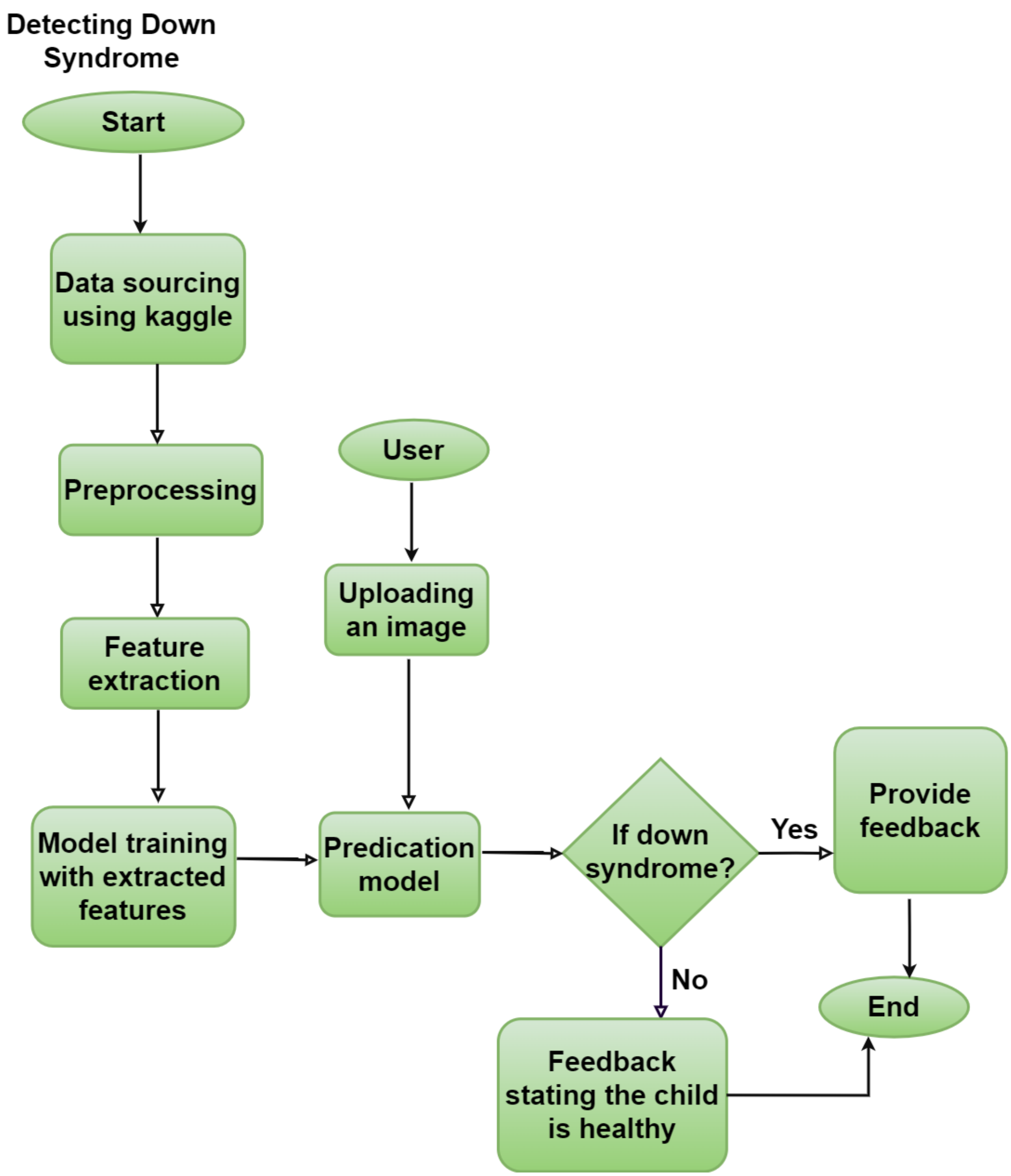


*Figure 7 -Flow chart*

## 3.2 Software Solutions

### 3.2.1 Development Process

Agile methodology is a dynamic and iterative approach to software development and project management that emphasizes flexibility, collaboration, and customer-centricity. Unlike traditional waterfall models, where projects follow a linear, sequential process from planning to delivery, Agile breaks down the project into smaller, manageable units called "sprints." Each sprint typically lasts between one to four weeks and focuses on delivering a specific piece of functionality or a working increment of the software. This incremental delivery allows teams to continuously integrate and test new features, making it easier to respond to changes and adapt to evolving customer needs [10].

At the heart of Agile methodology is the principle of iterative development, where teams work in short cycles to develop, review, and refine their product. This iterative process allows for continuous feedback and improvement, ensuring that the final product is closely aligned with the customer's requirements. Agile teams often work closely with stakeholders, holding regular meetings such as daily stand-ups, sprint planning sessions, and sprint reviews to discuss progress, address challenges, and realign goals as needed. This close collaboration fosters transparency and ensures that all team members are aligned on the project's objectives and status.

Another key aspect of Agile is its emphasis on cross-functional teams. In an Agile environment, teams are typically composed of individuals with diverse skill sets, including developers, testers, designers, and business analysts. This diversity allows teams to handle all aspects of product development within the sprint, from initial concept through to testing and deployment. The cross-functional nature of Agile teams encourages collaboration and knowledge sharing, breaking down silos and ensuring that everyone is working towards a common goal.

Agile also promotes a strong focus on customer satisfaction. By delivering small, functional pieces of the product early and often, customers can see tangible progress and provide feedback throughout the development process. This feedback loop is crucial, as it allows the team to make adjustments based on real-world usage and customer insights, rather than assumptions made during the initial planning phase. Agile's customer-centric approach ensures that the final product is not only functional but also meets or exceeds the expectations of its users.

Furthermore, Agile methodology is built on the concept of continuous improvement, both in terms of the product and the processes used to develop it. After each sprint, Agile teams conduct a retrospective meeting to reflect on what went well, what didn't, and how processes can be improved in the next sprint. This constant evaluation and adjustment help teams to fine-tune their workflows, improve efficiency, and address any issues before they become larger problems. The iterative nature of Agile allows for rapid experimentation, learning, and adaptation, which is essential in today's fast-paced and ever-changing business environment.

The Agile Manifesto, which was published in 2001, outlines the core values and principles of Agile methodology. It emphasizes individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan [11]. These values reflect the flexible, adaptive and people-focused nature of Agile, which is designed to handle the complexities and uncertainties of modern software development.

When implementing a complex and multifaceted system like EnlightenDs, Agile methodology becomes particularly important and highly beneficial. EnlightenDs, with its focus on assessing cognitive development, enhancing pronunciation skills, improving mathematical abilities, and identifying interests and talents in students, involves various interrelated components that need to be developed, tested, and refined. Agile's iterative and flexible nature makes it the ideal framework for managing the development of such a system.

One of the key reasons Agile is crucial for EnlightenDs is its emphasis on iterative development. EnlightenDs involves complex algorithms, including Convolutional Neural Networks (CNNs) for feature extraction, Natural Language Processing (NLP) for pronunciation analysis, and machine learning models for predictive analytics. Developing these sophisticated components in one go would be risky and could lead to missed opportunities for improvement. By using Agile, the development team can build the system in small, manageable increments called sprints. Each sprint focuses on developing a specific feature, such as the cognitive assessment model or the gamified pronunciation activities. This iterative approach allows the team to deliver a functional prototype early, gather feedback, and make necessary adjustments before proceeding to the next sprint.

Agile also facilitates close collaboration and continuous feedback, which is essential for a system like EnlightenDs that aims to meet the diverse needs of students, educators, and parents. By involving stakeholders in regular sprint reviews, the development team can ensure that the system aligns with user expectations and educational goals. For instance, during the development of the mathematical skill enhancement component, teachers and education specialists can provide insights on how well the system's adaptive quizzes align with curriculum standards and learning outcomes. This feedback can be quickly incorporated into subsequent sprints, ensuring that the final product not only functions well but also meets the specific needs of its users.

Moreover, Agile's focus on adaptability is particularly advantageous for EnlightenDs, given the rapid advancements in educational technology and artificial intelligence. As new techniques in AI and machine learning emerge, or as educational standards evolve, the system may need to be updated or reconfigured. Agile's flexible nature allows the development team to pivot and integrate these new advancements without disrupting the entire project. For example, if a more effective method of detecting cognitive development through drawings becomes available, the team can implement this change in a future sprint without overhauling the entire system.

Cross-functional teams, a hallmark of Agile, are also crucial when developing EnlightenDs. The system requires expertise in several domains, including AI, software engineering, educational psychology, and user experience design. Agile promotes the formation of cross-functional teams that bring together these diverse skills, enabling the team to handle all aspects of the project within each sprint. This integrated approach ensures that the system's various components, from the AI-driven drawing analysis to the user-friendly web application interface, are developed in harmony. Cross-functional collaboration also fosters innovation, as team members from different disciplines can contribute unique perspectives and solutions.

Additionally, Agile's customer-centric approach is vital for the success of EnlightenDs. The primary users of EnlightenDs are students, but it also serves educators and parents who rely on the system for insights into a child's development. Agile's iterative delivery model ensures that these stakeholders can interact with the system early in the development process and provide real-time feedback. For instance, parents can test the user interface for ease of use, or educators can evaluate the accuracy and educational value of the feedback provided by the system. This ongoing interaction ensures that the final product is not only technologically sound but also user-friendly and educationally effective [12].

Finally, Agile's principle of continuous improvement aligns perfectly with the long-term goals of EnlightenDS. After each sprint, the team conducts a retrospective to discuss what went well, what didn't, and how processes can be improved in the next sprint. This constant reflection and adaptation lead to a higher-quality product. For a system like EnlightenDS which will be used to influence the education and development of children, continuous improvement is not just a technical necessity but a moral imperative. The development team's commitment to refining and enhancing the system at every stage ensures that EnlightenDS remains a cutting-edge tool for educational assessment and development.

In conclusion, Agile methodology is not just a suitable approach for implementing EnlightenDS it is the optimal one. The iterative development cycles, continuous stakeholder feedback, adaptability, cross-functional collaboration, customer focus, and commitment to continuous improvement make Agile the best choice for building a system as complex and impactful as EnlightenDS. By employing Agile, the development team can ensure that EnlightenDS is not only robust and reliable but also responsive to the evolving needs of its users, ultimately delivering a product that truly enhances student development.

### 3.2.2 Requirement Gathering

**Conducting Interviews =** Interviews will be conducted with teachers, caretakers, and other professionals at Senehasa Research Center in order to garner vital ideas on the cognitive development of children having Down's syndrome. We assume that these people can provide useful information concerning strengths and weaknesses of Down syndrome children in the cognitive domain, especially in those aspects related to language, memory, adaptive behavior, and social skills. Furthermore, the views of parents concerning the children's cognitive abilities will be sought through conferences in order to establish strengths and areas that may require additional help. The professional and parental views would be helpful in deriving a holistic view of the child's cognitive development, thus guiding how to formulate educational strategies and interventions tailored to individual children.

**Observations =** We will carry out direct observations at Senehasa Research Center to closely observe how children with Down syndrome normally interact with cognitive tasks. We will go out to spend some time with the children during activities that form part of their daily routine, observing them while engaging in various cognitive challenges. We will have a special focus on concentration levels, strategies for processing information, and striking behavior patterns and learning characteristics that appear to be influential on their cognitive development. We will be particularly concerned about the children's unique cognitive behaviors, as they will yield most of the essential information in the shaping of individually oriented intervention and support strategies.

**Survey =** We conducted a survey concerning knowledge and perceptions of Down syndrome, with specific questions relating to cognitive development. We had a wide array of respondents answer the survey. The many responses that we got helped us a great deal. The results of the survey showed the level of understanding and recognition of the importance of research into cognitive development for children with Down syndrome. The survey will help immensely in understanding any gaps in knowledge or even misconceptions across the community. Findings, therefore, will guide us in refining how we put across our research, that it is both impactful and of significance to a bigger audience.

To illustrate the findings, a few of the survey responses will be included below.

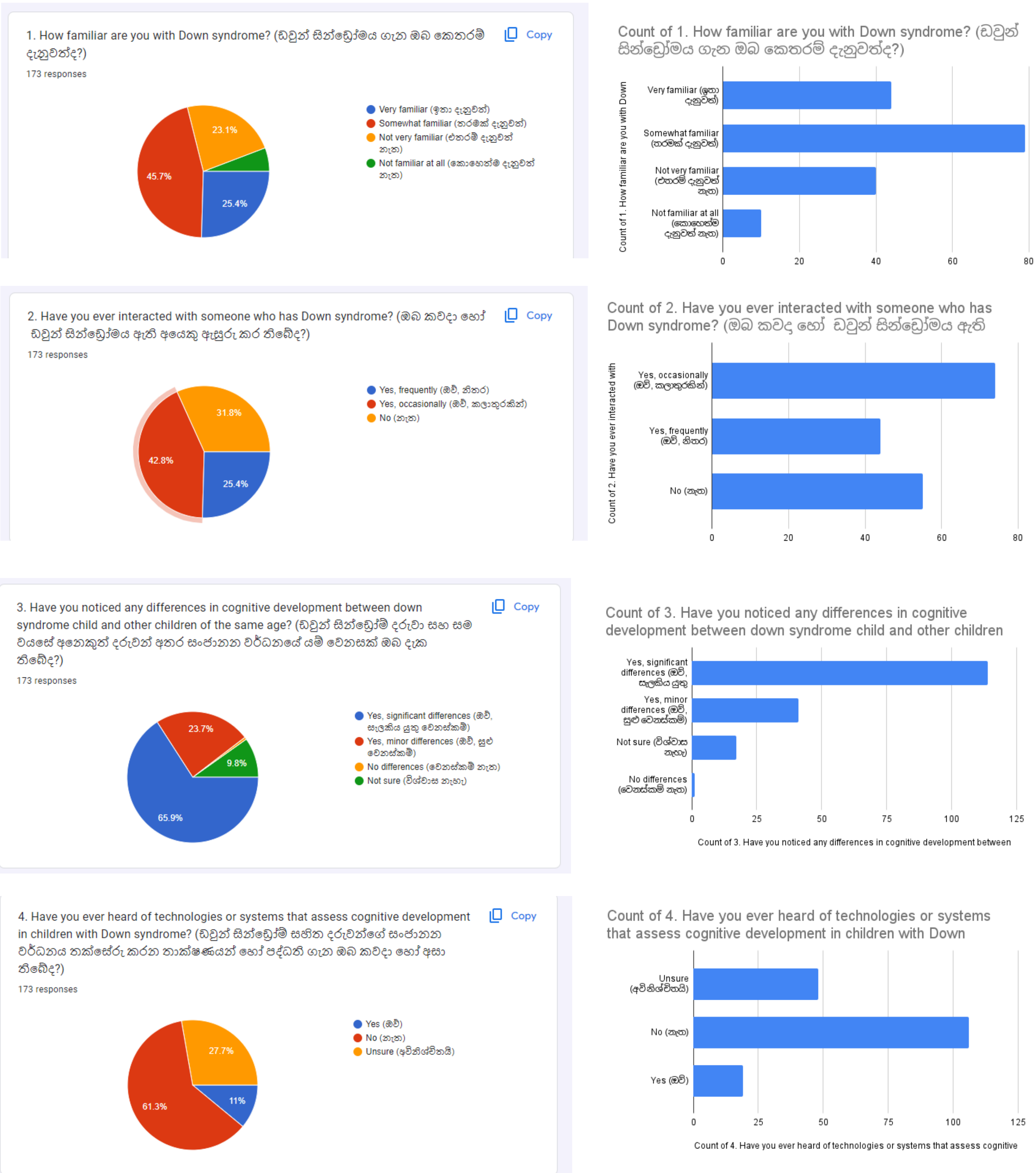


*Figure 8 - Survey responses*

Positive survey responses indicate a knowledgeable community with deep interactions and observations concerning Down syndrome and cognitive development. General awareness and familiarity with assessment technologies would suggest that, at large, there is little or no resistance to the use of such tools in the evaluation and enhancement of cognitive development.

The findings raise the importance of educating members of the general public and professionals on issues surrounding Down syndrome and cognitive development. We can progress from what is already known and build from there, setting any disparities and misconceptions straight. The positive contact with assessment technologies points toward promising directions for further research studies and practical applications.

Overall, these results from the survey prove that we have a sound base of knowledge and interest that can help us fine-tune our research and outreach activities for maximum impact and relevance.

\

# 4. PROJECT REQUIREMENTS

## 4.1 Functional Requirements

1. **Enable users to upload drawings**
   This requirement enables users to easily upload their drawing or image to the system. It involves making of a user interface where a user can select and upload their files.

2. **Ability to assess whether there is a lack in the cognitive development**
   This will include checking the uploaded drawings for any evidence of cognitive developmental delays or problems.

3. **Ability to extract features using CNN**
   This requirement focuses on using CNNs to analyze and extract meaningful features from the images.

4. **Ability to automatically preprocess uploaded images**
   Resizing: All images are resized to a standard dimension, such as 224x224 pixels, as will be fed into the CNN.
   Normalization: Pixel values should be scaled to a range suitable for the CNN, for example, from 0 to 1 or –1 to 1.
   Conversion: Based on the requirement of the CNN, the images will have to be converted into grayscale or adjusted for color channels.

5. **Generate a cognitive assessment score based on standardized criteria from the extracted features.**
   At the end, it should compute a score reflecting the cognitive assessment based on pre-defined standards.

6. **Provide feedback on the cognitive assessment.**
   This gives appropriate, relevant and useful feedback to users according to the results they attain from cognitive assessments.

## 4.2 Non-Functional Requirements

1. **Availability**
   The system should be operational and available to users when they need it.

2. **Reliability**
   The ability of the system to perform consistently without failure over time.

3. **User friendly**
   The system should be designed to be user friendly and understand for the intended users.
4. **High performance**
   The system should be able to operate efficiently and effectively.

5. **Security**
   The system should ensure that it will protect user data and information from unauthorized access and breaches.

6. **Maintainability**
   The ability of updating and repairing the system.

## 4.3 Technical Requirements

1. **Machine Learning**
   Enabled EnlightenDS system to analyze and learn from the dataset of hand-drawn images so that it may predict cognitive development based on the patterns detected in the drawings.

2. **Convolutional Neural Networks (CNN)**
   Automatic visual features extraction from hand-drawn images, such as lines, shapes, and patterns. These features are very important in determining the accuracy of the drawing and hence assess the cognitive development.

3. **Image Processing**
   It prepares the hand-drawn images for analysis using CNN. This includes resizing, normalizing, and augmenting the images to ensure that the model can effectively learn from the dataset and make accurate predictions.
4. **React**
   It is used for the user interface (UI) where users can upload their hand-drawn images. It manages interaction between the user and the back-end in ensuring a seamless experience when they get feedback on their cognitive development based on their drawings.

5. **Java Script Libraries**

This provides the most vital tools and components to make the development of your web application easier. This makes very important features act on the website, such as picture uploading, dynamic content rendering, or making responsive designs.

6. **Tensor Flow**

   TensorFlow is a framework for training and implementing a machine learning model. It provides the tools necessary to build, train, and test a model designed to predict cognitive development from the extracted features in hand drawings.

7. **Python**

   All data preprocessing, model development and integration with TensorFlow are done in Python. This ranges from loading the dataset, preparing images, training the CNN to the definition of prediction logic.

8. **Hand Drawing Recognition**

   It involves analyzing uploaded drawings to assess how accurately they match the expected patterns. This analysis helps in evaluating cognitive development, providing feedback based on how well the drawing features align with the standardized model.

## 4.4 Design

### 4.4.1 Use Case Diagram


*Figure 9- Use case diagram*

### 4.4.2 Test Cases

| |
|---|
| **Test case ID:** T01 |
| **Test title:** Checking preprocessing techniques |
| **Test priority (High/Medium/Low):** High |
| **Module name:** Image Preprocessing |

| |
|---|
| **Description:** This test case ensures that the system properly applies preprocessing techniques to a sample drawing, preparing it for further analysis. |
| **Pre-conditions:** The drawing is uploaded into the system |

| Test ID | Test Steps | Expected Output | Actual Output | Result (Pass/Fail) |
|---|---|---|---|---|
| T01 | 1. Apply preprocessing techniques such as resizing, noise reduction, and normalization. | The drawing is resized to a standard resolution, noise is reduced, and the image is normalized | • The drawing was successfully resized, noise was effectively reduced, and the image was normalized, making it suitable for analysis | Pass |

*Table 2 - Test case 01*

| |
|---|
| **Test case ID:** T02 |
| **Test title:** Feature Extraction Using CNN |
| **Test priority (High/Medium/Low):** High |
| **Module name:** Feature Extraction |
| **Description:** This test case verifies that the CNN correctly extracts key features from a preprocessed drawing, which are essential for cognitive assessment |
| **Pre-conditions:** The drawing has undergone preprocessing |

| Test ID | Test Steps | Expected Output | Actual Output | Result (Pass/Fail) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| T02 | 1. Input a preprocessed drawing into the CNN model<br><br>2. 2. Run the CNN to extract key features such as edges, shapes, and textures | Key features such as edges, shapes, and textures are accurately identified and extracted by the CNN. | The CNN accurately identified and extracted key features, including edges, shapes, and textures, aligning well with the expected results. | Pass |

*Table 3 - Test case 02*

| | | | | |
|---|---|---|---|---|
| **Test case ID:** T03 | | | | |
| **Test title:** Model Training with Labeled Data | | | | |
| **Test priority (High/Medium/Low):** High | | | | |
| **Module name:** Model Training | | | | |
| **Description:** This test case ensures that the CNN model is trained effectively using labeled data based on standardized scoring criteria | | | | |
| **Pre-conditions:** Labeled data is available for training | | | | |
| **Test ID** | **Test Steps** | **Expected Output** | **Actual Output** | **Result (Pass/Fail)** |

| | | | | |
|---|---|---|---|---|
| T03 | 1. Provide the labeled data set to the CNN model<br><br>2. Begin the training process with the labeled data, monitoring loss and accuracy over time | The CNN model's loss decreases over time, indicating learning, and the model achieves high accuracy on validation data | The CNN model's loss decreased as expected, and the model achieved high accuracy on the validation data, demonstrating effective learning | Pass |

*Table 4- Test case 03*

| |
|---|
| **Test case ID:** T04 |
| **Test title:** Cognitive Development Assessment |
| **Test priority (High/Medium/Low):** High |
| **Module name:** Assessment and Classification |
| **Description:** This test case checks whether the trained CNN model can correctly assess a new drawing and classify the cognitive development stage of the child |
| **Pre-conditions:** The CNN model is trained and ready for deployment |

| Test ID | Test Steps | Expected Output | Actual Output | Result (Pass/Fail) |
|---|---|---|---|---|
| T04 | 1. Input a new, unseen drawing into the trained CNN model<br><br>2. Run the model to assess the drawing and | The model correctly classifies the cognitive development stage of the child based on the drawing, matching the | The model accurately classified the cognitive development stage of the child, matching the standardized criteria and providing correct assessment | Pass |

| | | | | |
|---|---|---|---|---|
| | classify the cognitive development stage | standardized criteria | | |

*Table 5- Test case 04*

### 4.4.3 Wireframes

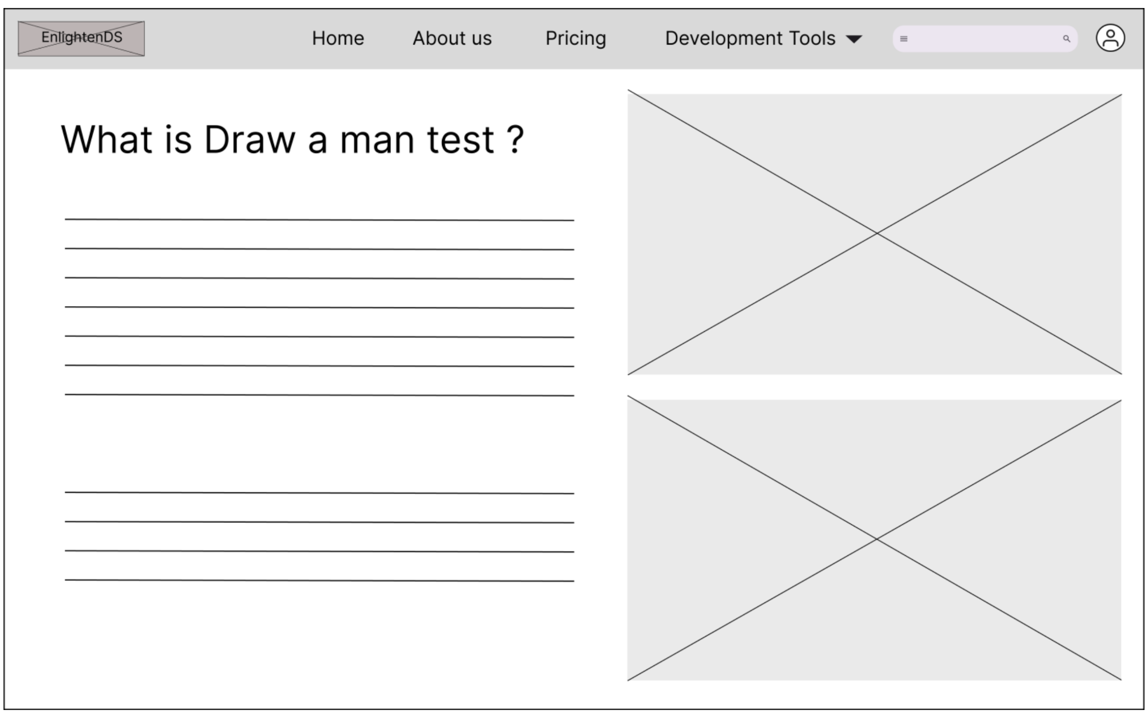


*Figure 10- Draw a man dashboard*

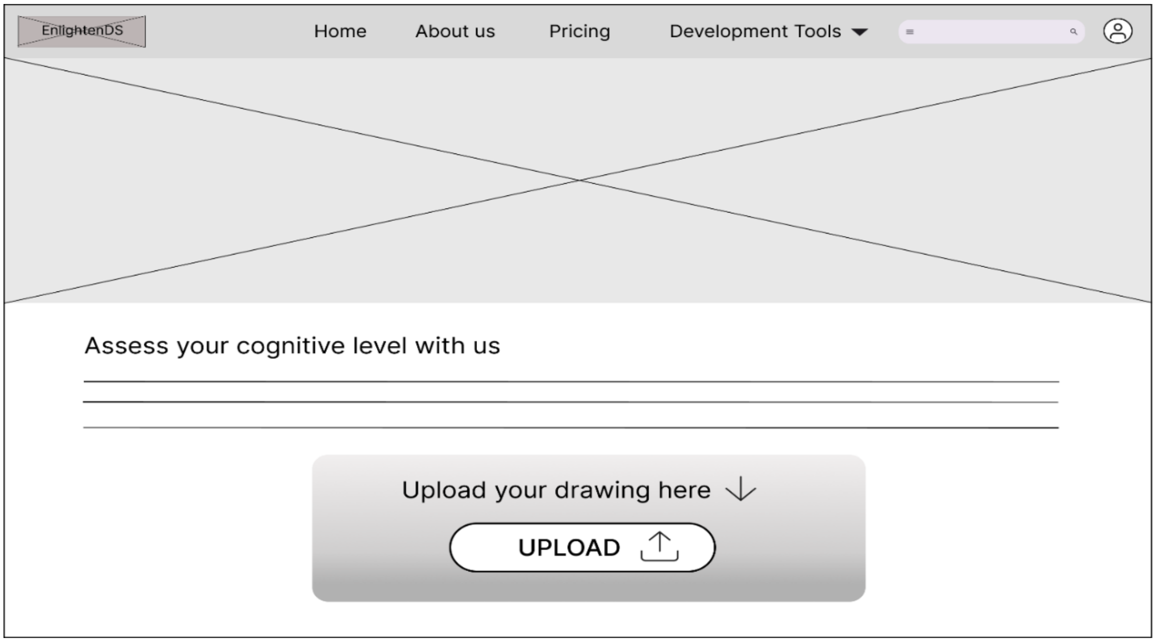


*Figure 11 - Image upload wireframe*

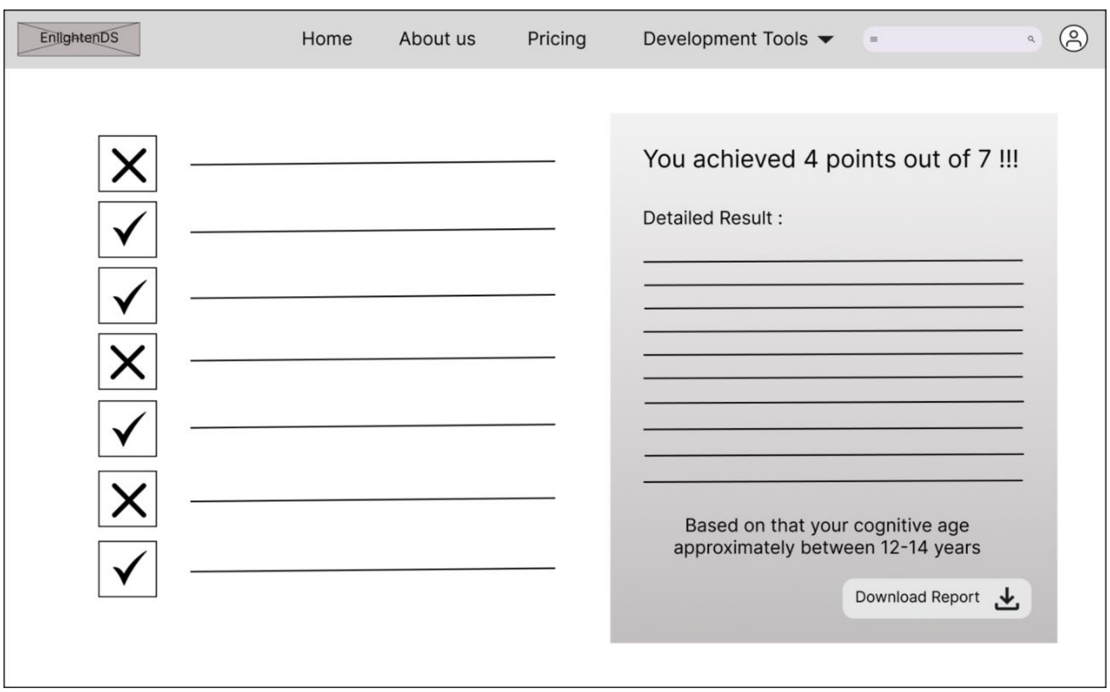


*Figure 12-Check cognitive level wireframe*

# 5. COMMERCIALIZATION PLAN


*Figure 13 - Commercialization plan*

A structured commercialization plan is needed for a number of reasons: First, it brings in sufficient revenues to sustain and grow our project revenues that will be reinvested into further development and refurbishment of the app. Second, it ensures that our solution remains both accessible to individual users and large educational institutions. Third, it clearly outlines how the market would be reached, such as building campaigns, allies, and alliances through educational standards that move along or follow regulatory standards for education and data privacy globally.

With a growing demand for educational technology, particularly in the area of cognitive development and early childhood education, our system "EnlightenDS" is a great opportunity to meet this demand. The very critical recognition of early cognitive assessments and developmental support only seems to be on the rise, hence creating a demand for such tools that are more accessible and effective for the use of parents, educators and schools at large. This will make these tools widely available for us so that they could make a significant contribution to children's cognitive development in a sustainable way.

A tiered subscription model for a number of different use categories has been formulated to be flexible and scalable. It is free through the **Basic plan**, which will give available basic cognitive level assessments, basic communication improvement activities and limited personalized quizzes on subjects like math. This plan, therefore, serves as an entry point to our solution, letting users explore and experience the key features of our app with no financial commitment. This implies that with the offering of a free version, the entry barrier will be low and a lot more kids can enjoy our tools, alike.

For users who want to have a more immersive and complete experience, there is a **Premium Plan** priced at $10 per month. This plan incorporates all the features of the Basic Plan and on top of this, it will include full access to personalized quizzes built by the user, emotion-based activities, mood detection and advanced summary reports. These features are designed for enabling deeper insight and customized support; hence, the Premium Plan should be adopted by parents and teachers who are keen on close monitoring and enhancement of cognitive development of the child.

Lastly, realizing that the educational institutions have special requirements, we have a **School Plan** offered for $30 per month, where all the features provided in the Premium package are extended in full to up to 40 students. This plan is especially useful for schools and special education centers to help them incorporate our cognitive development tools into their curriculum and do so at a very affordable price. Through a solution that can serve many, we make it easier for institutions to support large groups of children systematically and cheaply.

# 6. BUDGET

| Component | Amount |
|---|---|
| Travelling cost | 10000 |
| Server & Hosting charges | 25000 |
| Internet Charges | 15000 |
| Total | 50000 |

*Table 6- Budget*

The budget for "EnlightenDS" has been carefully planned to cover all the important costs needed to develop and launch our cognitive assessment tool. It involves an amount of LKR 50,000, carefully planned to cover all the essential costs associated with the development and deployment of our cognitive assessment tool, EnlightenDS. The total budget is broken down into three key components.

First, we allocated LKR 10,000 for Traveling Costs. This amount is for traveling related to team meetings, collaboration with educational institutes, and any fieldwork that might be required for collecting user feedback or on-site demonstrations of our tool. This will ensure that we get to meet and interact face-to-face with our stakeholders. This is very important in the refinement of our solution to meet real-world needs.

This comes with the largest portion of the budget, LKR 25,000, for Server and Hosting Charges. This will be very instrumental in maintaining the infrastructure required to support our app. Reliable server hosting ensures that our platform remains open to users always, ensuring seamless operation and data security.

Finally, LKR 15,000 has been allocated for Internet Charges. Since we are going to use cloud-based services and collaborate remotely, stable internet with high speed is one of the essential requirements for the day-to-day running of the project from research to development, testing, and communication.

# 7. GANTT CHART

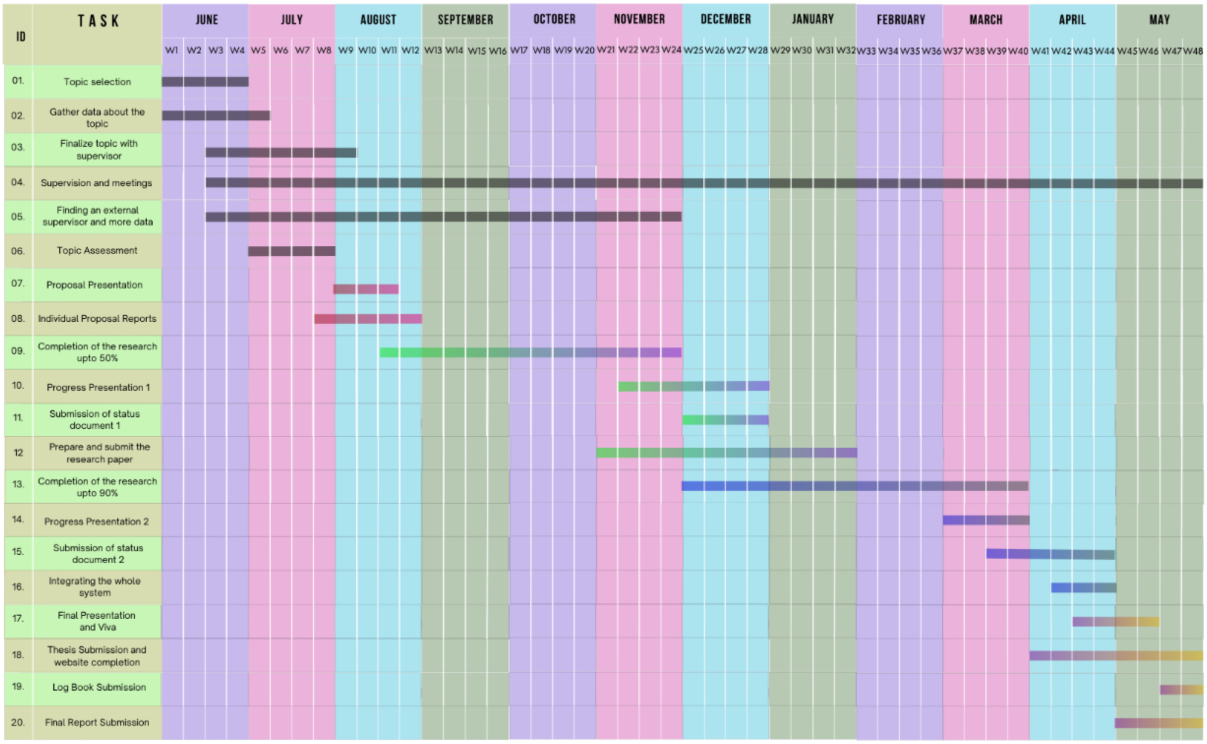


*Figure 14- Gantt chart*

# 8. WORK BREAKDOWN CHART

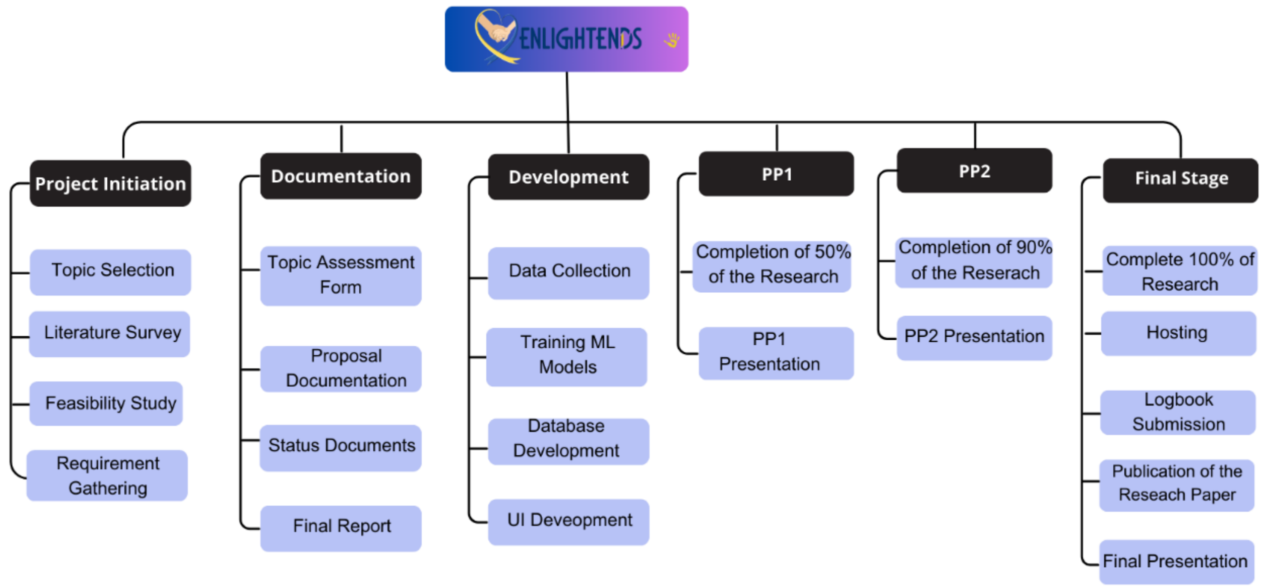


*Figure 15- Work Breakdown Chart*

# 9. REFERENCES


[1] Fidler, Deborah J, "infants and young children - LWW," April 2005. [Online]. Available: https://journals.lww.com/iycjournal/fulltext/2005/04000/the_emerging_down_syndrome_behavioral_phenotype_in.3.aspx.

[2] Kim H, Kim S, Kim J, Jeon H, Jung D, "PubMed Central," 2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5344833/.

[3] Tania Irena Gunawana, Wirawan Istionob, "ResearchGate," 07 2024. [Online]. Available: https://www.researchgate.net/publication/382230056_An_Android_Augmented_Reality_Application_to_Improve_Cognitive_Skills_in_Color_Recognition_for_Down_Syndrome_children.

[4] Marcela Tenorio, Paulina S. Arango, Andres Aparicio, "ResearchGate," 12 2023. [Online]. Available: https://www.researchgate.net/publication/376508369_BENDI_Improving_Cognitive_Assessments_in_Toddlers_and_Children_with_Down_Syndrome_Using_Stealth_Assessment?_sg=tYE6dFZiEbTOckjtAUbdVFA-zDvjjGnemZ91kx4y2SipQ_CPmwfkrRJEOOwt9Y9eUVmpQFCKuQHcbcg&_tp=eyJjb250Z.

[5] Yuko Yamauchi, Sayaka Aoki, Junko Koike, Naomi Hanzawa, Keiji Hashimoto, "ResearchGate," 11 2018. [Online].Available:https://www.researchgate.net/publication/329260953_Motor_and_cognitive_development_of_children_with_Down_syndrome_The_effect_of_acquisition_of_walking_skills_on_their_cognitive_and_language_abilities.

[6] Schofield, Diana W, "medscape," 26 12 2018. [Online]. Available: https://emedicine.medscape.com/article/917629-overview?form=fpf.

[7] Wajeeha Abdul Ahad, Fazaila Ehsaan, Noreen Fatima, Faiza Yousaf, Rabia Qamar, Ambreen Sadaf, Sehar Ashraf,"ReserachGate,"022020.[Online].Available:https://www.researchgate.net/publication/350874523_Cognitive_Impairments_in_Children_with_Down_Syndrome.

[8] Angela F Lukowski, Helen M Milojevich, Lauren Eales, "PubMed," [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/30846049/.

[9] "Boston children's hospital," [Online]. Available: https://www.childrenshospital.org/conditions/down-syndrome.

[10] "opentext," [Online]. Available: https://www.opentext.com/what-is/agile-development#:~:text=Agile%20development%20is%20a%20broad,short%2C%20time%2Dboxed%20sprints

[11] A. Alliance, "Manifesto for Agile Software Development," 2001. [Online]. Available: https://agilemanifesto.org/.

[12] Bartosz, "blurify," [Online]. Available: https://blurify.com/blog/high-performing-agile-teams-what-are-their-characteristics/.

# 10. APPENDICES

Survey Link = https://forms.gle/QAtP4zw7gkEtuYQ47

Plagiarism Report =

24-25J-228 - IT21296314.pdf

ORIGINALITY REPORT

| 9% | 7% | 3% | 5% |
| --- | --- | --- | --- |
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
| --- | --- | --- |
| 1 | www.researchgate.net<br>Internet Source | 2% |
| 2 | Submitted to University of Wales Institute, Cardiff<br>Student Paper | 1% |
| 3 | fastercapital.com<br>Internet Source | 1% |
| 4 | www.physio-pedia.com<br>Internet Source | 1% |
| 5 | www.childrenshospital.org<br>Internet Source | 1% |
| 6 | Submitted to Wilmington University<br>Student Paper | <1% |
| 7 | Yuko Yamauchi, Sayaka Aoki, Junko Koike, Naomi Hanzawa, Keiji Hashimoto. "Motor and cognitive development of children with Down syndrome: The effect of acquisition of walking skills on their cognitive and language abilities", Brain and Development, 2018<br>Publication | <1% |

| | | |
|---|---|---|
| 8 | www.university-directory.eu<br>Internet Source | <1 % |
| 9 | Submitted to Sri Lanka Institute of Information Technology<br>Student Paper | <1 % |
| 10 | amraan.net<br>Internet Source | <1 % |
| 11 | www.mdpi.com<br>Internet Source | <1 % |
| 12 | Submitted to University of Bolton<br>Student Paper | <1 % |
| 13 | Submitted to Universiti Teknologi Malaysia<br>Student Paper | <1 % |
| 14 | Submitted to Coventry University<br>Student Paper | <1 % |
| 15 | Submitted to The Hong Kong Polytechnic University<br>Student Paper | <1 % |
| 16 | pspbookcom.oss-eu-west-1.aliyuncs.com<br>Internet Source | <1 % |
| 17 | Submitted to City University<br>Student Paper | <1 % |
| 18 | afribary.com<br>Internet Source | <1 % |

| | | |
|---|---|---|
| 19 | mpm2019.eu<br>Internet Source | <1 % |
| 20 | 101autism.com<br>Internet Source | <1 % |
| 21 | Submitted to University Of Tasmania<br>Student Paper | <1 % |
| 22 | su.diva-portal.org<br>Internet Source | <1 % |
| 23 | Submitted to Macao Polytechnic Institute<br>Student Paper | <1 % |
| 24 | Mehdi Ghayoumi. "Generative Adversarial Networks in Practice", CRC Press, 2023<br>Publication | <1 % |
| 25 | Jin Xu. "Image Data Visualization and Communication System Based on Sensor Network Simulation and Visual Feature Extraction", Measurement: Sensors, 2024<br>Publication | <1 % |
| 26 | afirse.ie.ul.pt<br>Internet Source | <1 % |
| 27 | meral.edu.mm<br>Internet Source | <1 % |
| 28 | Marcela Tenorio, Paulina S. Arango, Andrés Aparicio. "BENDI: Improving Cognitive Assessments in Toddlers and Children with | <1 % |

Down Syndrome Using Stealth Assessment",
Children, 2023
Publication

| | | |
|---|---|---|
| 29 | Pawan Singh Mehra, Dhirendra Kumar Shukla. "Artificial Intelligence, Blockchain, Computing and Security - Volume 2", CRC Press, 2023<br>Publication | <1 % |

| | | | |
|---|---|---|---|
| Exclude quotes | Off | Exclude matches | Off |
| Exclude bibliography | On | | |

*Figure 16-Plagiarism Report*