ENLIGHTEN DS: ADVANCED TECHNOLOGIES FOR SKILL ENHANCEMENT AND TALENT RECOGNITION IN CHILDREN WITH DOWN SYNDROME

Methsahani K.K.S.P

IT21292972

Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science (Hons) in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

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DECLARATION

I declare that this is my own work and this dissertation1 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 my 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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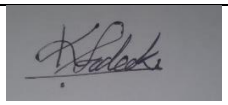
Methsahani K.K.S.P	IT21292972	

The above candidate has carried out research for the bachelor's degree Dissertation under my supervision.

Signature:  Date: 2025-04-11

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ABSTRACT

This component introduces a multimedia-based system designed to assess and identify the dominant talents of children with Down syndrome by recognizing their distinct interaction patterns and cognitive abilities. From this component, evaluates three key areas such as motor skills, learning skills, and drawing skills, using tailored digital tools for each. Motor skills are assessed through a digital piano interface. In here interaction time and the number of keys which user entered are considered to take the finger movements. This category will provide insight into the child's musical abilities. Learning skills are evaluated using an AI-driven quiz module, which generates quizzes customized to each child's cognitive level, analyzing both interaction time and quiz scores. Drawing skills are calculated by measuring interaction time on a digital drawing platform according to the similarity score. This component captures the child's drawing skills based on the similarity score. In here reference image provided the user to do the drawing. Then the user can do the drawing by referring to the reference image. Then the system will provide a similarity score. The system records and analyzes the number of attempts and interaction time across these activities to determine the child's most prominent talent. By focusing on the area with the highest selection count, the system identifies where the child is talented the most. It then generates a notification for parents, offering valuable insights into the child's dominant talent. This comprehensive and adaptive assessment approach is designed to support parents and educators in recognizing and nurturing the unique strengths of children with Down syndrome. By accurately identifying the talents of these children, the system helps guide further development and support in the areas where they show the greatest aptitude. Ultimately, the system aims to provide a deeper understanding of each child's abilities, ensuring that their talents are recognized and encouraged in a way that aligns with their individual needs and potential.

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List of Abbreviations

Artificial Intelligence	AI
User Interface	UI

1. INTRODUCTION

Down syndrome is a genetic condition caused by the presence of an extra copy of chromosome 21, also known as trisomy 21. It is the most common genetic cause of intellectual disability, occurring in approximately 1 in every 700 live births [1]. Individuals with Down syndrome often face a range of challenges, including cognitive delays, difficulties with memory and executive functioning, and an increased risk of certain medical conditions [2].

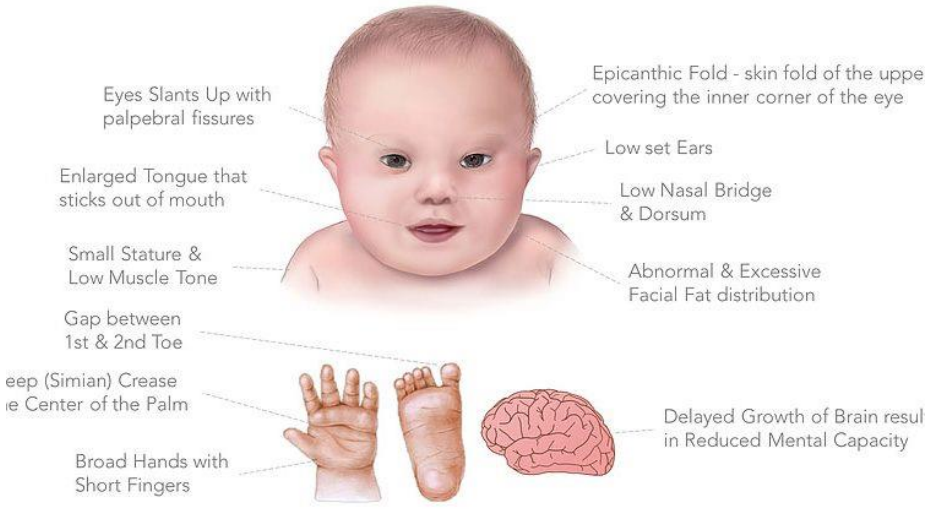


Figure 1 Symptoms of down syndrome

However, the severity of these challenges varies, with some individuals experiencing mild symptoms while others face more significant difficulties [3]. Despite these challenges, many individuals with Down syndrome possess various strengths and talents. Advances in healthcare, education, and social support have significantly improved their quality of life. As a result, individuals with Down syndrome are living with more fulfilling lives. Also. increasingly included in mainstream schools, workplaces, and community activities, where they make valuable contributions [4]. Education plays a critical role in helping children with Down syndrome develop their abilities. However, traditional teaching methods often fail to address their unique learning needs [5]. This has highlighted the importance of developing specialized educational materials tailored specifically for them. Multimedia technology offers an innovative approach to creating engaging and effective learning tools, particularly for teaching fundamental concepts such as numbers and basic mathematics [6]. The goal is to develop customized multimedia resources that support their learning

process and contribute to improved educational outcomes [7]. This research report on identifying the talents of children with Down syndrome focuses on the importance of supporting their creativity and tailoring educational methods to their needs. The proposed system is designed to analyze how these children interact with various activities to find their strongest talent. This approach aligns with the idea that children with Down syndrome can have unique creative abilities. Children with Down syndrome often struggle in traditional classrooms because of cognitive and motor challenges. However, research shows that they can excel in creative arts, like music and painting, when given the right tools and opportunities [8].

Proposed system included components like assessing the detection of down syndrome, enhance pronunciation skills, enhance mathematical skills and identifying the interests and talents of children with Down syndrome. When it comes to the talent's identification component, which uses AI- generated quizzes, a digital painting platform, and a piano-based recital assessment provides these children with accessible and engaging ways to express themselves. In this component focuses on tracking interaction time, calculating the score of quiz, drawing similarity score calculation and measure ability to do finger movements. By analyzing this data, proposed components offer a more complete evaluation of their abilities compared to traditional methods. This approach also matches findings that continuous exposure to creative arts benefits children with Down syndrome, helping them develop cognitive and motor skills while boosting their emotional and social well-being. Additionally, notifying parents about their child's talents can help guide further support tailored to the child's strengths. Overall, proposed research builds on existing knowledge and offers a new tool that could lead to more personalized and effective development strategies for children with Down syndrome.

When it comes to implementation of talent identification component, MongoDB, Express.js, React.js, Node.js (MERN stack), JavaScript libraries, Artificial intelligent (AI) and VS code kind of tools and technologies are used.

Using this component, down syndrome children can take several benefits like identifying their hidden talents and improving their existing talent and enjoy their day-to-day lifestyle.

1.1 Background literature

This section mainly explains the previous research work which went through before starting off this project.

Based on the selected research topic and the scope of this study, the main focus is on identifying the talents of children with Down syndrome. The research specifically explores three key skill areas such as motor skills, learning abilities, and painting or drawing skills. It is often observed that children with Down syndrome tend to show natural strength in one of these specific areas. However, a major limitation found in previous studies is the absence of a proper system to accurately identify these individual talents [10][12]. While existing research provides valuable insights, the majority tend to emphasize the difficulties and developmental challenges faced by these children rather than offering practical tools for talent recognition [10].

J. Janier et al. [9] proposed their research by considering learning, matching and counting skills of down syndrome children. In this research, a learning model helps to identify numbers and matching modules helps to match numbers. When it comes to the count module it helps to identify the value or amount. These modules consist of a couple of activities and provide platform to numbers related learning.

W. Needham et al. [10] have been considered writing with a pencil typing with a keyboard using a knife and fork to cut kind of activities through the connection between the size of muscle and muscle group involved to movements. This approach helps to identify the ability of motions related activities. Authors stated that according to the size of muscle and muscle group involve to movements directly involve the ability of motion related activities.

Similarly, while Hickman et al. [12] explore adaptive learning strategies such as advanced question randomization techniques to improve educational assessment systems, their research does not directly address the needs of children with Down syndrome or their specific talents. This leaves a clear gap in the development of integrated, personalized systems aimed at identifying and nurturing individual strengths in this special population.

A.S.T. Sampath et al [11] proposed an e- learning education system. In this research authors have used voice recognizing and image recognizing techniques to identify the drawing abilities of down syndrome children. This research is to measure the drawing ability of down syndrome children.

J Svendsen and others [13] have been done an analysis based on vision for motor behavior patterns in snowboarding games. The authors have introduced a parabolic bounding box concept to capture local changes of a posture while downs syndrome child perform motion. Authors stated that the

proposed system helps to capture body motions. They have considered normal and abnormal weight shifting patterns differences and a frequency of the patterns.

J. Jadan-Guerrero et al. [14] stated an early literacy process based on ready of frequency technology for down syndrome students. During their research work, authors have used graphical user interface, tangible user interface and traditional interface. Authors have used teachers and six down syndrome children to their study for analyzing the results. They have used cardboard cards, digital cards, 3D letters and low-cost toys which have RFID tags. For this study, they did their analysis of the interaction of the provided inputs.

According to the research [15][16][17] offer useful contributions to the process of developing and testing motor skills and the use of multimedia learning for children with Down syndrome, they are mainly concerned with the assessment of pre-existing abilities or the overall utilization of multimedia resources.

1.2 Research gap

In this section will describe the identified research gaps from existing research papers.

Several existing research studies have made valuable contributions to the field of Down syndrome education and skill development. For instance, the work by J. Janier et al. [9] focuses primarily on learning-related abilities such as matching and counting. While this research provides a solid foundation in early learning, it is limited to basic cognitive activities and does not explore broader learning assessment methods such as quizzes or interactive modules that could offer deeper insights into a child's academic abilities.

According to the studies which are done by Nadeem and others [10] identified connection between the size of muscle and muscle group involved to movements. They consider writing with a pencil typing with a keyboard using a knife and fork to cut kind of activities. As an improvement they can use their findings to improve the skills of down syndrome children.

A. S. T. Sampath and others have done research about e- learning education system [11]. They have been used handwritten images and voice samples of down syndrome children. They are checking the drawing ability of down syndrome children by using voice recognizing and image recognizing. They haven't used that to improve those identified skills. Based on the findings, authors only measure drawing ability. They can use that to improve the skills of down syndrome children, as their future works.

According to the research study of [12], they have studied programming assessment technical. According to their finding randomization technique is better than question shuffling.

According to the research [15][16][17] offer useful contributions to the process of developing and testing motor skills and the use of multimedia learning for children with Down syndrome, they are mainly concerned with the assessment of pre-existing abilities or the overall utilization of multimedia resources. But our proposed component is different in that it not only evaluates but also incorporates interactive platforms (quiz, piano, and drawing) to discover and develop specific talents in children with Down syndrome. This progressive initiative of talent detection and nurturing is a new practice innovation, covering the gap of using technology in measuring and cultivating the special gifts of these kids.

Most of the research studies which have been done previously focus on challenges faced by children with Down syndrome [10]. There is no proper system available to identify the talented area of down syndrome children. Proposed component will help to identify the talented area of down syndrome children and provide a chance to sharpen up their talents. Without knowing the exact talent of down syndrome children, they will not be able to fine tune that. This component will help to identify that. This is not only a platform to identify the talents of down syndrome children, but also this component will provide a platform to enjoy and entertain their artistic skills.

	[9]	[10]	[11]	[12]	EnlightenDS
Identify learning skill	√	×	×	×	√
Identify recital skill	×	×	×	×	√
Identify the talented area	×	×	×	×	√
Identify drawing skills	×	×	√	×	√
Generate quizzes using AI	×	×	×	√	√

Table 1 Research gap

1.3 Research problem

Children with Down syndrome often have unique strengths and abilities in specific areas such as learning, motor skills, and drawing. Identifying these talents early is essential for providing effective support, boosting their confidence, and promoting their personal growth.

However, there are currently few interactive tools specifically created to recognize and evaluate the individual talents of children with Down syndrome. Traditional assessment methods used in schools are often unsuitable for these children, as they do not address their unique cognitive, behavioral, and motor skills needs. Existing evaluation methods usually focus on identifying delays or difficulties rather than uncovering and nurturing hidden or emerging talents. This limitation means many children with Down syndrome may not get the support needed to fully develop their strongest skills, whether academic, artistic, or musical.

This research aims to solve this issue by creating an interactive, technology-based system designed specifically for children with Down syndrome. The system will have a simple, engaging interface to measure performance across three key areas such as learning through quizzes, motor skills through a piano application, and artistic skills through digital drawing. By tracking data like task completion times, number of attempts, quiz score, drawing similarity, number of piano key count, and each category efficiency, the system will analyze and identify each child's strongest skill area. The goal of this research is to provide a meaningful way to discover and support the talents of children with Down syndrome. This system will help them to flourish by building on their natural strengths.

Below research problems considered during the implementation of this component.

- **Data interpretation:**

  One of the core challenges is accurately interpreting interaction data such as quiz scores, piano key counts, or drawing similarity scores to make meaningful conclusions about a child’s abilities. This involves creating proper criteria to distinguish between general engagement and actual talent of down syndrome children.

- **Period of interaction time calculation:**

  Understanding how much and how well a child interacts with each activity can help show which area they are most talented in.

- **Parent notification and feedback:**

  Another significant challenge lies in how the system communicates the findings to parents or guardians. The results need to be shared in a clear, simple, and supportive manner, ensuring that caregivers understand the identified talents and are encouraged to take steps that further develop these skills.

  Ultimately, the goal of this research is not only to create a platform for identifying talent but also to contribute to a more inclusive and supportive environment for children with Down syndrome. By leveraging AI, machine learning, and interactive technologies, the proposed system aims to provide a personalized and enjoyable experience that both identifies and nurtures the individual strengths of each child while empowering parents and educators with the insights they need to support their journey.

1.4 Objectives

1.4.1 Main objective

The main objective of this study is to develop an intelligent system capable of identifying the individual talents of children with Down syndrome by analyzing their performance in motor skills, learning abilities, and artistic expression. The system aims to provide clear feedback to parents or caregivers, helping them understand the child's strongest area of talent for further development.

1.4.2 Sub-objectives

1. Identify Recital Skill:

Implement a piano interface to measure interaction time and finger movement sequences.

Track the number of attempts and analyze the sequence to determine the child's skill in music or recital.

2. Assess Learning Skill:

Develop AI-generated quizzes to the cognitive level of children with Down syndrome.

Measure the time spent on quizzes and analyze scores to evaluate the child's learning capabilities.

3. Evaluate Drawing Skill:

Create a digital painting platform where children can paint freely.

Track interaction time and analyze the paintings to assess artistic talent.

4. Talent Identification and Notification:

Analyze the data from all three skill areas to determine the highest selection count and score.

Generate a notification for parents highlighting the child's area of strongest talent.

5. Helps to improve the identified talent of Down syndrome children:

This component will provide the identified talented area by analyzing the gathered and calculated data based on the use of down syndrome children.

6. Train a machine learning model analyze it correctly (using Random Forest):

Analyze the collected data to predict the most talented area for each child.

7. Provide a final output:

To provide a final output that visually displays the child's most talented area. This should help caregivers and educators better understand the child's strengths.

2. METHODOLOGY

Through this chapter, explains about the methodology which is used to implement the proposed component and will provide a detailed explanation about the implementation

2.1 System architecture diagram

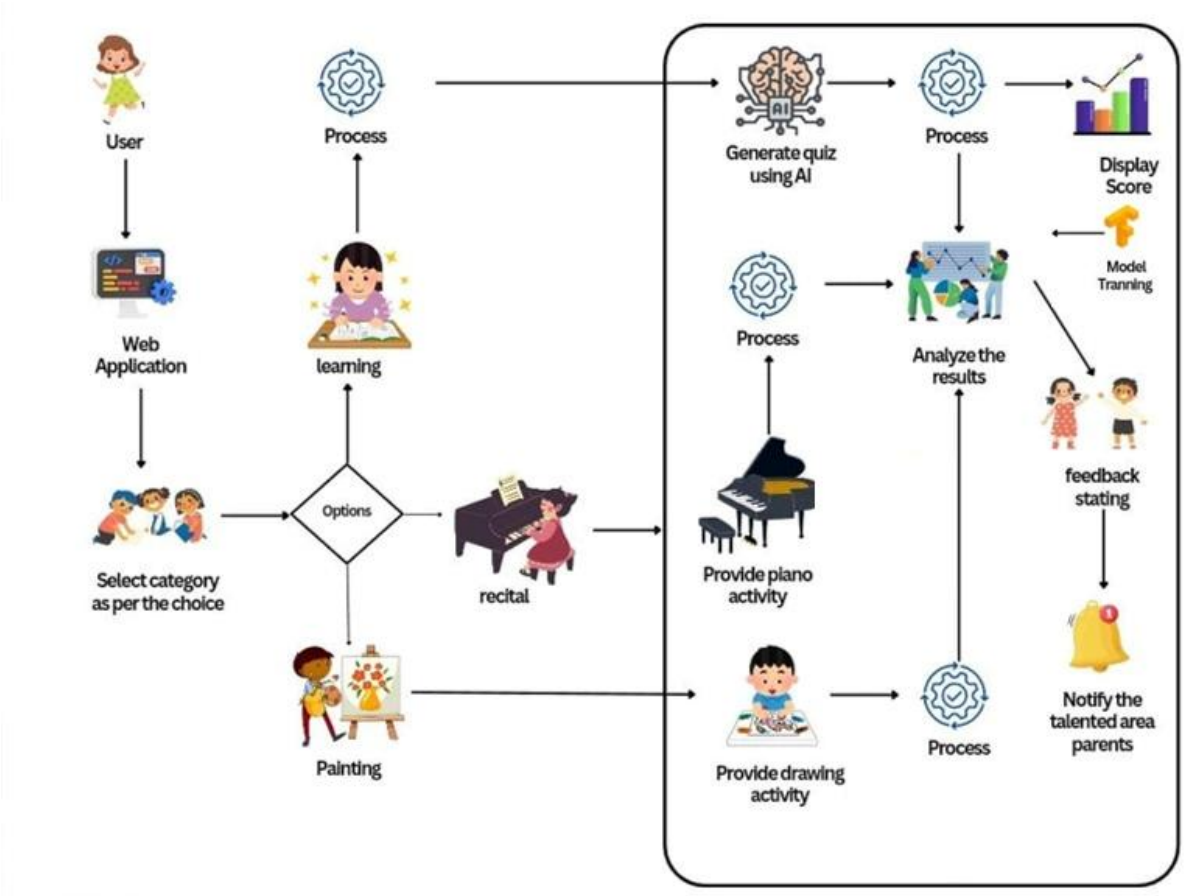


Figure 2 Component diagram

This component will provide an interface to identify talent of down syndrome children. First of all, the user needs to sing into the system. Then users will navigate to the home page. After the user can navigate to the talent identification page. Once the user navigates to this component the user will be able to select a category according to their choice. There are three main categories are there. Those are learning category, motor category for identify recital skills and drawing category.

Learning category includes quizzes which will be generated using AI. It implemented using lang chain to generate questions. If the user selected the learning category, it includes language related questions. The user navigates to the history of the list of quizzes. The resent quiz will display in the bottom of the list. All the quizzes which users receive are new once. Also, they can re-visit their previous quizzes using the list of historical quizzes. In here user will get 5 questions for one attempt. While the user is doing the quiz current score, the number of correct answers and number of wrong answers are displayed in the UI. After the user completes the quiz, the user will receive the score, number of correct answers and number of wrong answers and the time taken to complete the quiz. Multiple times users can attempt to quizzes by navigating to the learning category section. This section includes measuring scores and time period which user takes to complete the quiz as well. There are couple of conditions checking to take this at talented area. They are final score should be more than 3 and the time which the user spend to complete the quiz should in between 5 to 20 minutes. As basic parameters of this category will take the attempt count, scored marks, and time which the user spends to complete the quiz. Once user selected motor category system will provide a piano. It means a keyboard. By using this category, system will identify whether the user has a talent to recital skills or not. This keyboard is implemented using React.js. As basic parameters of this category to identify motor skill, the number of key counts which user played, and the user interacted time period considered. When identifying the talented area, couple of conditions considered in the motor skills category. Those are user should be interacted with this platform for a minimum of 5 minutes. Also, within 1 to 6 minutes the user should play between 100 to 250keys. within 6 to 10 minutes users should play 200 to 450keys. If the user met the above 2 conditions it should take as one attempt. If the user selected, the drawing category they will receive a drawing platform. User can draw pictures. UI will provide a reference image. Once user complete the drawing they need to select the compare button. Then system will display the similarity score. This category implemented using AI and visual comparison. As parameters to the analyzation the user interacted time period and similarity score considered. Based on the calculation parameters final analyzation happens. I implemented and trained a model to do this analyzation. From that analyzation system will identify the most interacted category of that down syndrome child. Once it identifies the system will implement to notify that talented area to their parents.

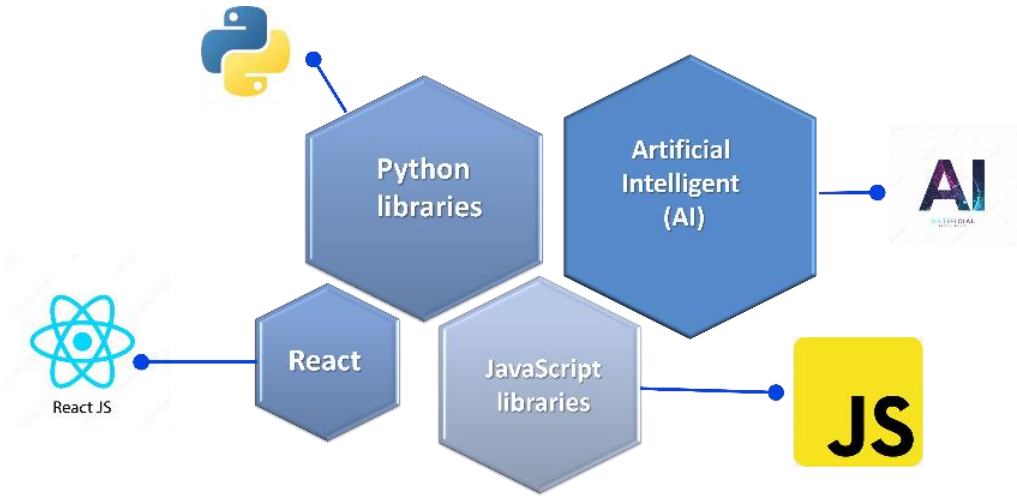


Figure 3 Technologies

In here mainly used python libraries to train the model. Above tool stacks will use to implement this component.

2.2 Flow Chart

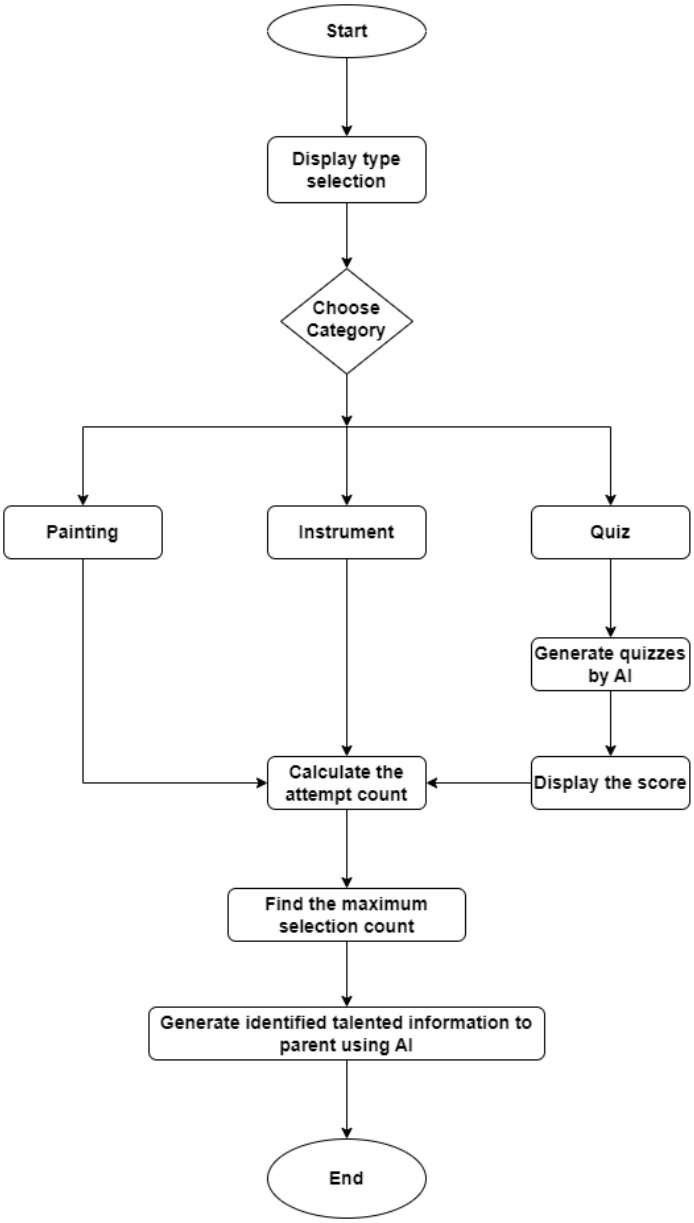


Figure 4 Flow Chart

2.3 Software Solution

2.3.1 Agile

In this research project, Agile methodology was adopted to efficiently manage the development process of the talent identification system designed specifically for children with Down syndrome aged 5 to 15 years. Agile emphasizes an iterative and collaborative approach, allowing the project to progress through continuous feedback and incremental improvements. Development tasks were divided into manageable segments which means sprints. Each sprint focused on specific functionalities such as the quiz platform, piano interaction module, and drawing assessment system.

In this component, quiz questions generated by AI, piano interactivity using Tone.js, and drawing similarity comparisons using OpenAI were continuously tested, evaluated, and improved across multiple iterations. The version control provided by GitHub facilitated collaboration and tracking of the project's evolution.

By following Agile practices, the team successfully incorporated stakeholder feedback, quickly adapted to emerging challenges, and maintained clear communication throughout the project lifecycle. This approach significantly contributed to creating a flexible, user-friendly, and highly effective talent identification platform tailored to the unique developmental needs of children with Down syndrome.

Figure 5 Agile methodology

2.4 Requirement gathering

In the initial stage we started the research work with requirements gathering phrase. This project is based on down syndrome children. In that case we found out a school which provides education to down syndrome children. “Senehasa Research Center” is the school which we selected to do our research work. We are gathering information through those students.

In the initial stage, we selected a doctor who is working with down syndrome children. We gathered information through that doctor and identified the research components correctly which we need to implement. From those discussions, we identified that, those down syndrome children talent for one specific area. In that case we confirmed that the features which we need to include in our research work. Also, did background studies through research papers and identified the existing research works which are done by other research.

Not only that, but also, we had couple of meetings with our supervisor who is Prof.Samantha Thelijjagoda and the co-supervisor, who is Dr. Junius Anjana. They also provided huge support to finalize the research components. In that way we gathered information to start our research work.

During this stage we did a survey to identify the persons feel about the research and how much they aware about down syndrome. The outcome of the gathered survey results as below. Here I have only attached the talent identification related survey results.

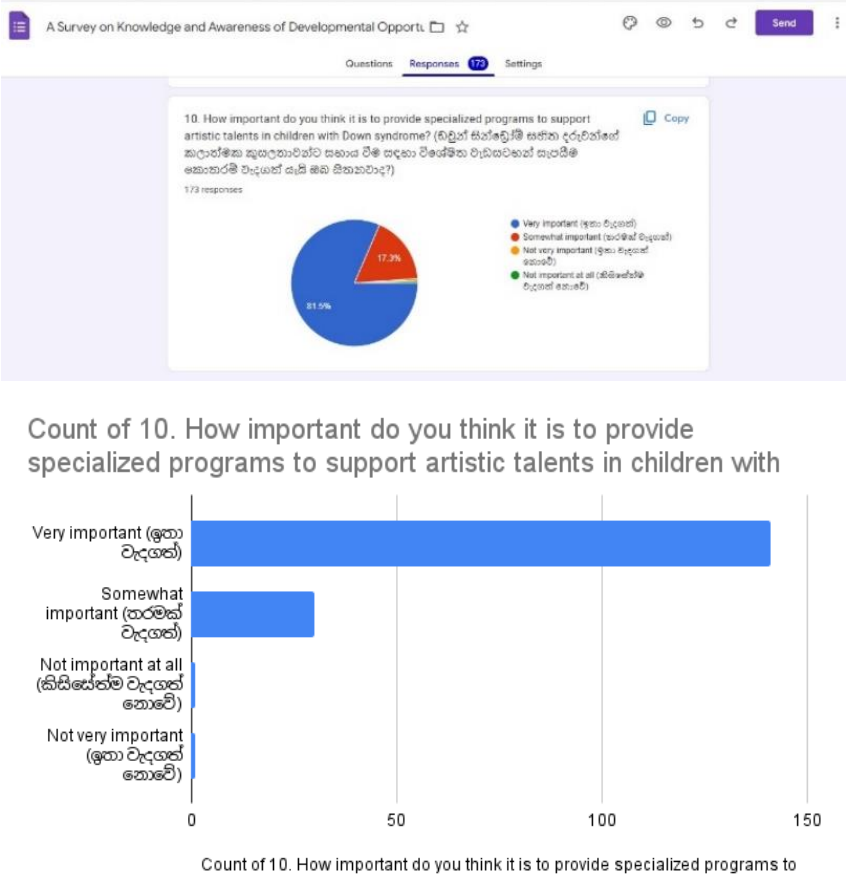


Figure 6: Survey results – 1

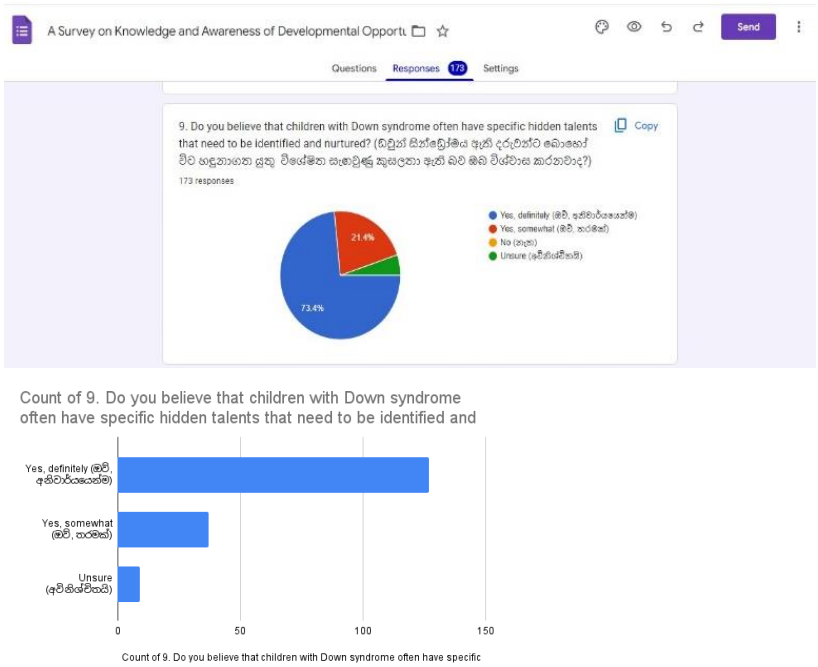
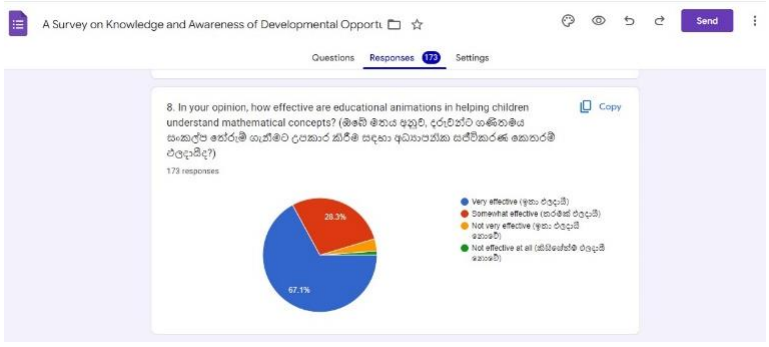


Figure 7: Survey results - 2



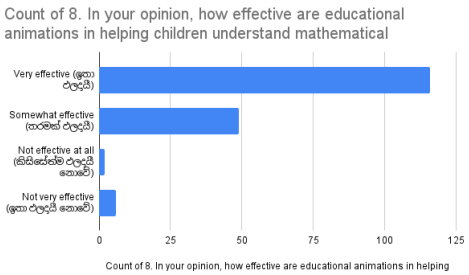


Figure 8: Survey results – 3

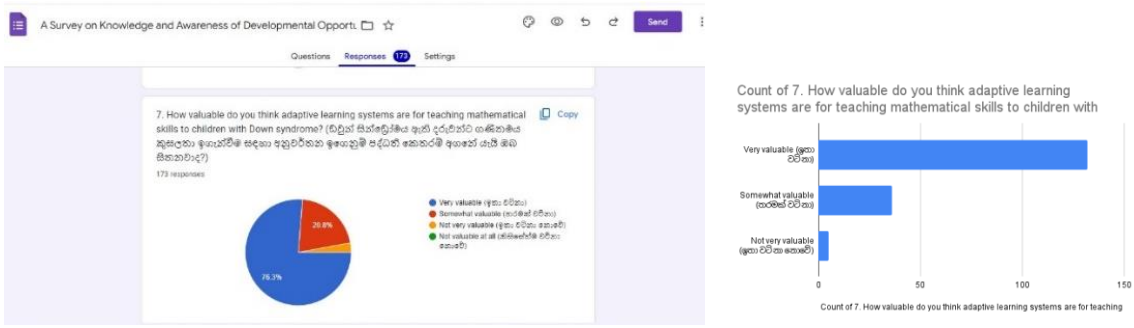


Figure 9: Survey results - 4

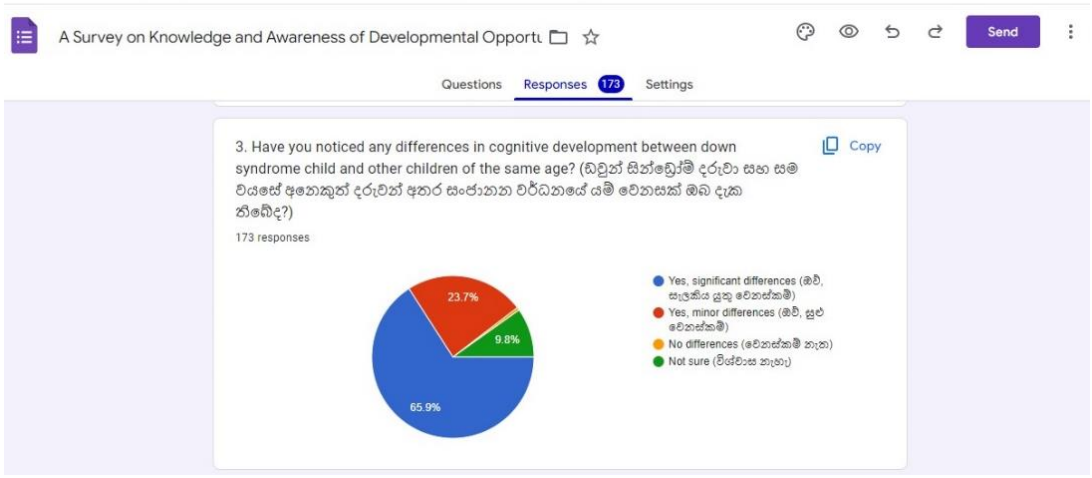


Figure 10: Survey results - 5

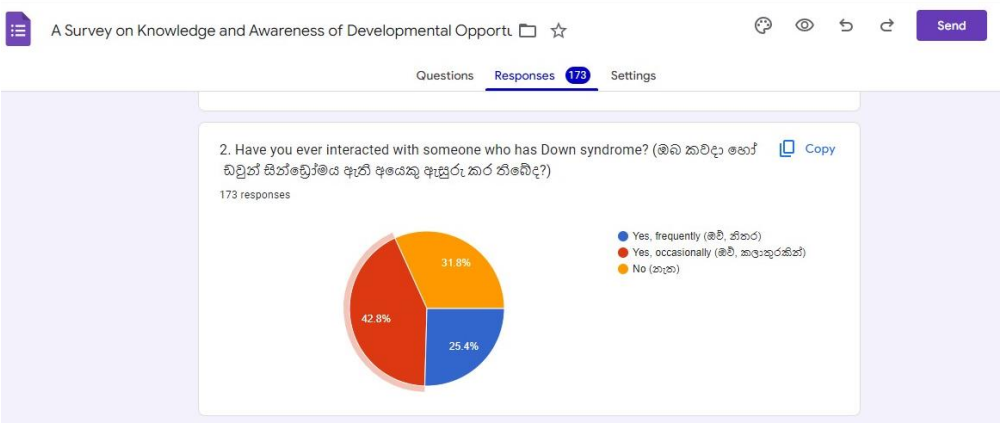


Figure 11: Survey results - 6

2.5 Project requirements

2.5.1 Functional requirements

Recital Skill Assessment

- The system should display a digital piano interface
- The system should record time spent interacting with the piano
- System should track and analyze the sequences of finger movements on the keyboard
- System should calculate and maintain scores based on interaction and sequence accuracy

Learning Skill Assessment

- The system should generate AI-generated quizzes based on the cognitive level of the child
- The system should ensure that no quiz shall be the same on every try.
- The system should keep track of the time spent with every quiz attempted.
- The system should provide a score for each quiz taken and subsequently save it for future reference.

Painting Skill Test

- The system must provide an online painting interface where children could create their pictures.
- The system keeps track of how much time the painting process took.
- The system saves and calculates the level of complexity, colors, and patterns involved in making such a painting, if applicable.

Talent Analysis and Reports

- It should compare the scores obtained in all three activities to find out which one has the highest score.
- After that, it needs to generate the summary report identifying the major talent area of the child.
- Finally, this program should inform the parents about the child's identified talent through a user-friendly notification.

2.5.2 Non-functional requirements

Usability:

- The system should have an intuitive and child-friendly interface.
- The system must be easily navigable by children with Down syndrome, with minimal assistance.

Performance:

- The system should generate quizzes in real-time with minimal delay.
- Interaction tracking should be real-time and accurate, with no noticeable lag.

Scalability:

- The system should be able to handle multiple children using it simultaneously, in case it is used in a classroom setting.

Security and Privacy:

- All user data must be securely stored and protected; especially sensitive information related to children.
- Data transmission should be encrypted to protect against unauthorized access.

Accessibility:

- The system should be designed with accessibility in mind, ensuring it is usable by children with different levels of Down syndrome.
- The platform should support assistive technologies if needed.

Maintainability:

- The system should be easy to update with new quizzes, piano exercises, and painting features.
- The system should be modular to facilitate future enhancements or changes.

2.5.3 Technology requirements

In this project, modern tools and technologies were carefully selected and combined to develop an effective system capable of identifying the talents of children with Down syndrome. The MERN stack, consisting of MongoDB, Express.js, React.js, and Node.js, was chosen to provide a robust and scalable foundation for the application. To do the model training Pyton language used. MongoDB served as the primary database for storing user interaction data and analysis results, ensuring efficient data retrieval and storage. Express.js and Node.js managed the backend operations, facilitating smooth communication between frontend and database, while React.js provided an interactive and user-friendly interface for quizzes, piano interaction, and drawing activities. Additionally, artificial intelligence (AI) and machine learning techniques were used to enhance the quiz generation and analytical capabilities of the system.

2.5.4 Tools

Visual Studio Code (VS Code)

Visual Studio Code was used as the main integrated development environment (IDE) for implementing the overall system. Its simple yet powerful features, such as intelligent code completion, integrated debugging, and built-in Git integration, allowed seamless development and testing. VS Code's extensive collection of extensions further improved productivity, providing a comfortable environment for developing the application's frontend and backend modules.

GitHub

GitHub played an essential role in this project by providing robust version control capabilities. It facilitated the tracking of changes, management of project versions, and allowed collaborative coding. With GitHub, the development process became streamlined, enabling easy recovery of previous versions and effective coordination among team members during different stages of development.

Google Colab

Google Colab was used extensively for training and testing the machine learning model designed for talent identification. This cloud-based platform offered access to powerful computational resources like GPUs, significantly speeding up the training process. Colab's user-friendly interface allowed for quick iterations of model experiments, immediate visual feedback through built-in visualization libraries, and effortless collaboration.

2.5.5 Technology

React.js

React.js is a popular JavaScript library, used for building interactive and user-friendly web applications. In this project, React.js was chosen to create the frontend interface of the talent-identification system for children with Down syndrome. React allowed the development of fast, responsive, and dynamic user experiences, such as quiz interactions, piano playing, and drawing activities. Its component-based approach made it easy to manage and update different parts of the application, ensuring smooth and enjoyable interactions for users.

Artificial Intelligence (AI)

Artificial Intelligence was integrated into the system to dynamically generate quiz questions and analyze user interactions. Specifically, AI was utilized to automatically create unique, language-related questions each time a quiz was initiated, enhancing the learning assessment experience.

Visual Comparison (OpenAI)

The drawing component leveraged OpenAI's advanced visual comparison capabilities to accurately assess similarity scores between reference images and user drawings. OpenAI's API allowed the system to objectively measure artistic accuracy, providing precise similarity percentages. This enabled reliable evaluation of artistic skills and ensured consistent, unbiased scoring of the drawings created by the students.

2.6 Testing & Implementation

2.6.1 Implementation

This section describes implementation related information about the talent identification component.

When it comes to the implementation part, the front end implemented using react.js backend implemented using node.js and MongoDB used for database. Random forest algorithm used to do model training.

Some major implementation points will summarized below.

In the drawing category section, drawing canvas, reference image, blusher, color pallet, eraser and compare score kind of features implemented. After the user do the drawing user can select the compare button. Then visual comparison will happen using AI. Then in the VS code terminal shows the reason to given that score.

In figure 13 as shown below, the code represents the calculation of drawing interaction time period. It used to do the analyzation of drawing category. Using that, time period which the user does the drawing in canvas is calculated. It will help to take accurate interaction time and able to remove the time period which user not doing the drawing while the drawing category platform is open.

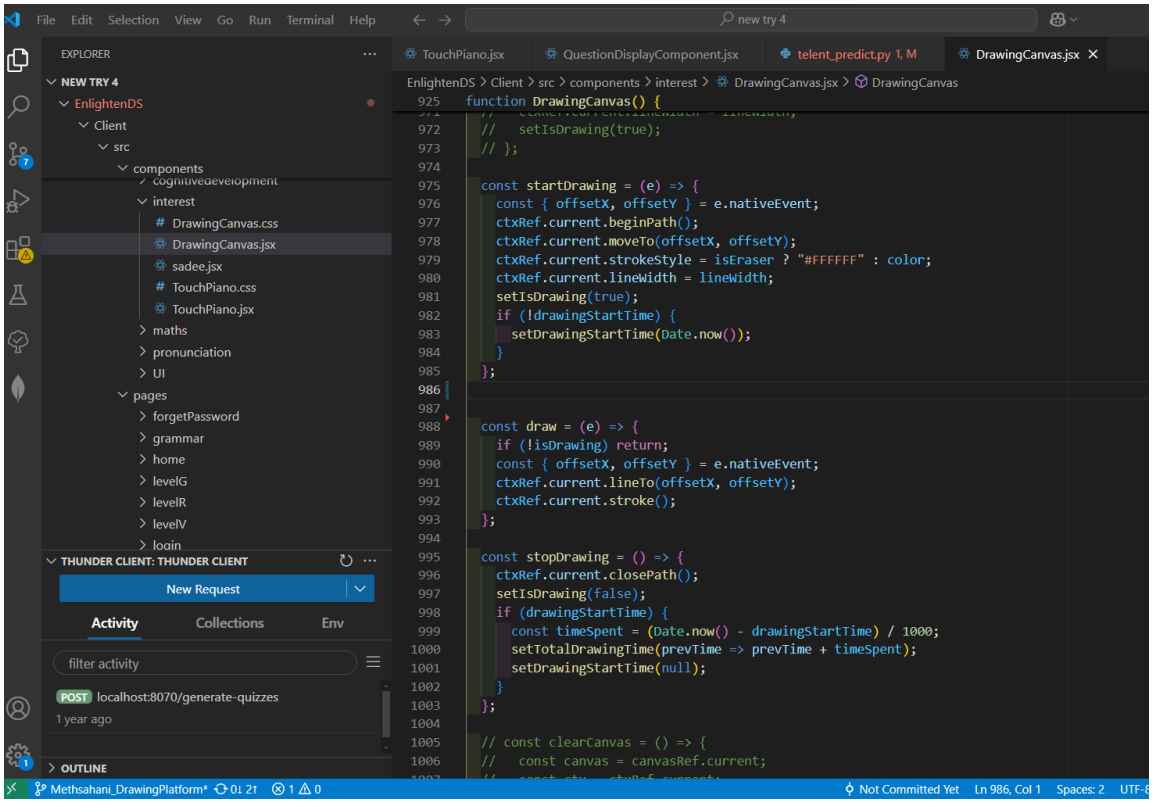


Figure 12 drawing time period calculations

In the piano category section, interactive piano simulator has been implemented. User able to play that using mouse clicks and if it is touch screen, user can play the keys using those keys. Tone.js used to generate the sound when user play the keys. In here piano key interaction time period calculation, number of key count user used to play the piano and saving functionality implemented.

In figure 14 shows the piano key count calculation related implementation.

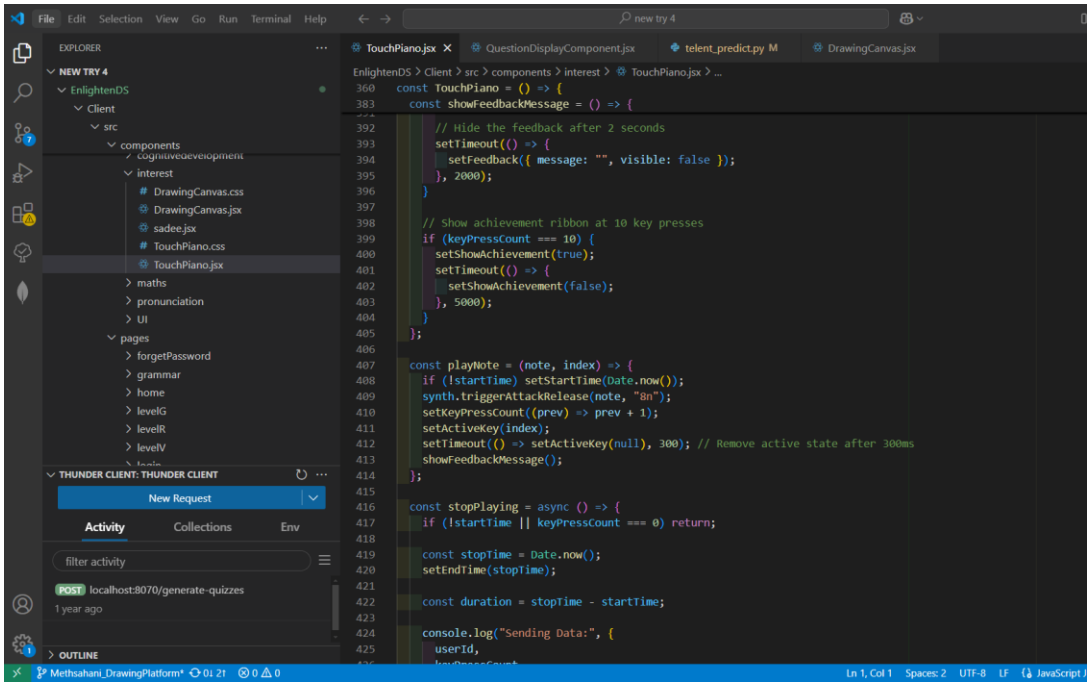


Figure 13 Interacted piano key count calculation

In the quiz category section, it is implemented using MERN stack and AI. From the talent identification page, user able to select the learning category. Then user can select beginner, intermediate or advanced subcategories. According to their selection they will get quizzes. In this quiz generation part implemented using AI. Once user selected a subcategory, new quiz is generated which includes 5 new questions. After user taking the next questions correction also happen. Then user can view the correct answer. Not only that number of correct answers, number of wrong answers and score are getting display in the top of the UI. Once user completed the quiz, UI implemented to display number of correct answers, number of wrong answers, final score and interaction time. Saving functionality also implemented in the UI. Once user save that those details getting store into the database.

In figure 15 shows the quiz generation-related main coding using open AI key

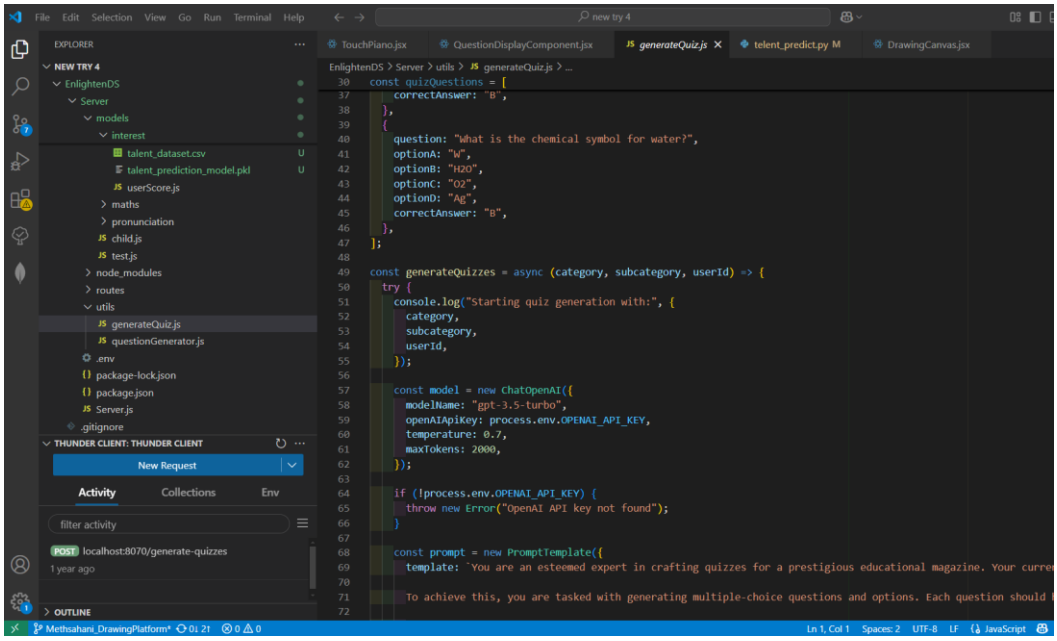


Figure 14 Quizzes generation part

In figure 16 represents the model training related implementation section. It used Random forest algorithm. FLASK API used to model.

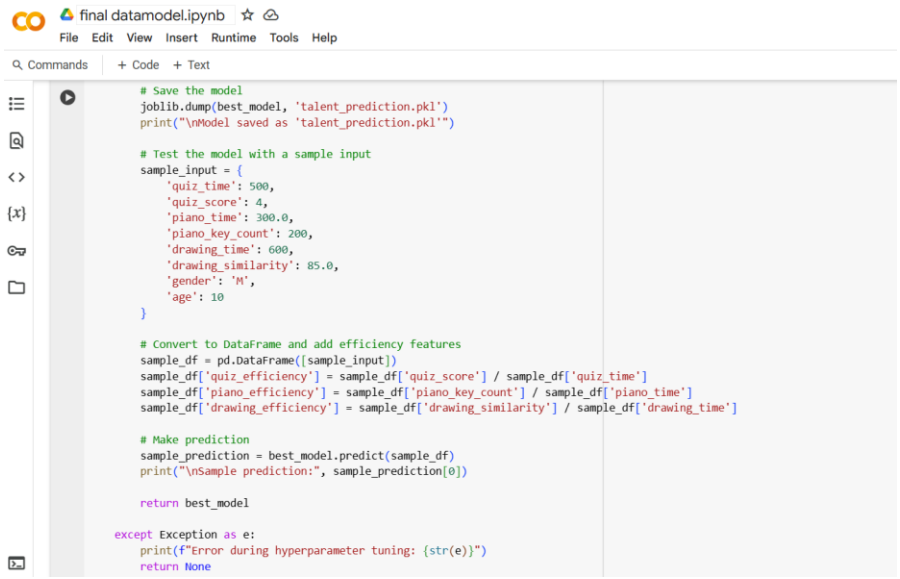


Figure 15 model training representation

2.6.2 Testing

In this stage testing related information describe. Not only does the final stage of implementation testing happens with the initial stage of coding implanting and integrating. During the implementation, code level white box testing happened. After developing and each component. Component wise functional testing completed. Integration testing included while doing the integration of each and every component. Once completed the overall project regression testing conducted to make sure there are no existing functionally break.

In figure 17 represents the test results of similarity score calculation and interaction time. Drawing platform related functionalities validation,

- Validated the testing similarity functionality – did a drawing and check whether the similarity score will getting populate correctly.
- Tested the saving functionality and checked whether it has been saved to the database.
- Tested the blusher color changing ability, blusher size changing ability and erasing functionality.

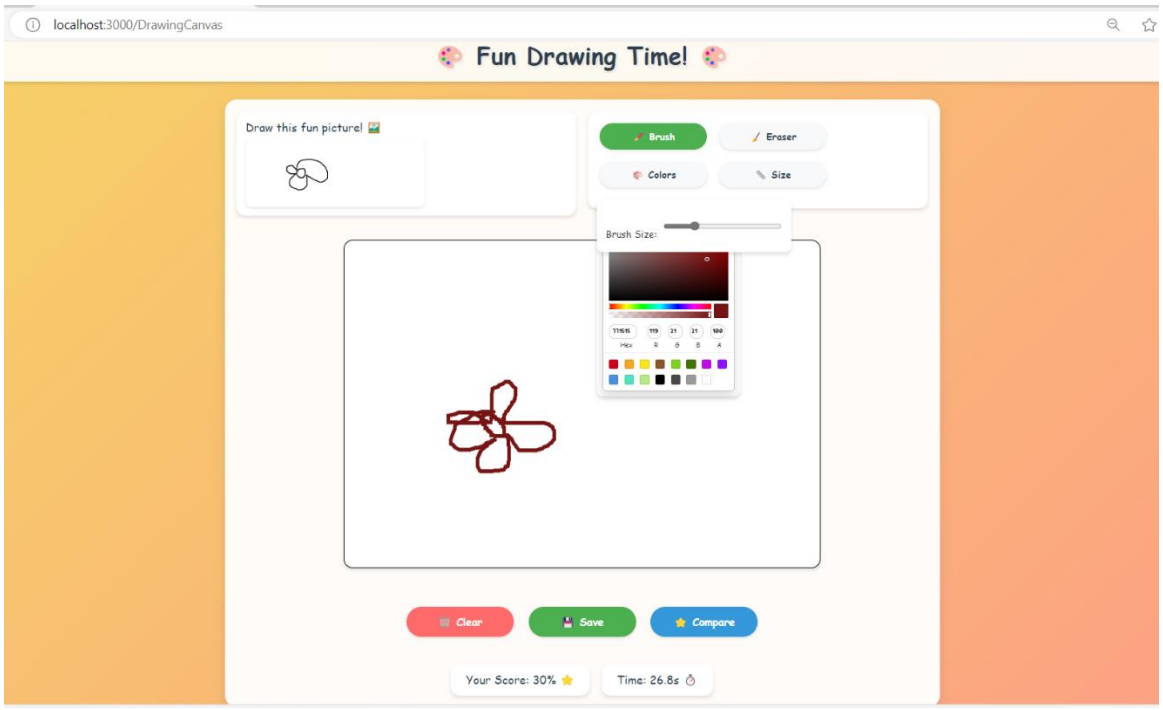


Figure 16 drawing similarity score validation

In figure 18 represents the test results of saving functionality and number of key count and interaction time functionalities validation. Also validated the tone generation.

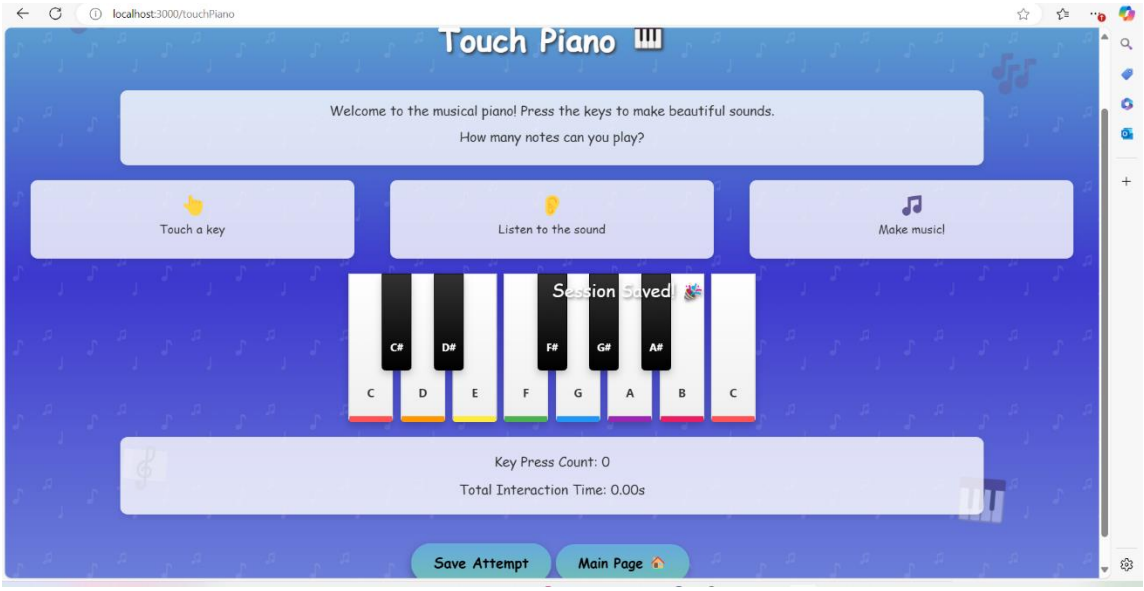


Figure 17 piano functionality validation

In figure 19, 20 represents the test results of quiz generation and score calculation validation. Validated the quiz generation according to the category and subcategory selection. Also validated the new question generation.

Figure 18 Quiz generation

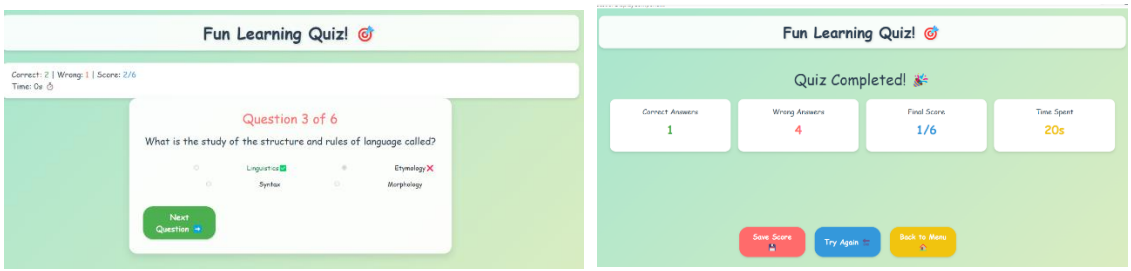


Figure 19 Quiz user interfaces

In figure 21 represents the validation of talented area prediction. FLASK API used to model. To do the validation, sent data through postman and checked whether the output is correct.

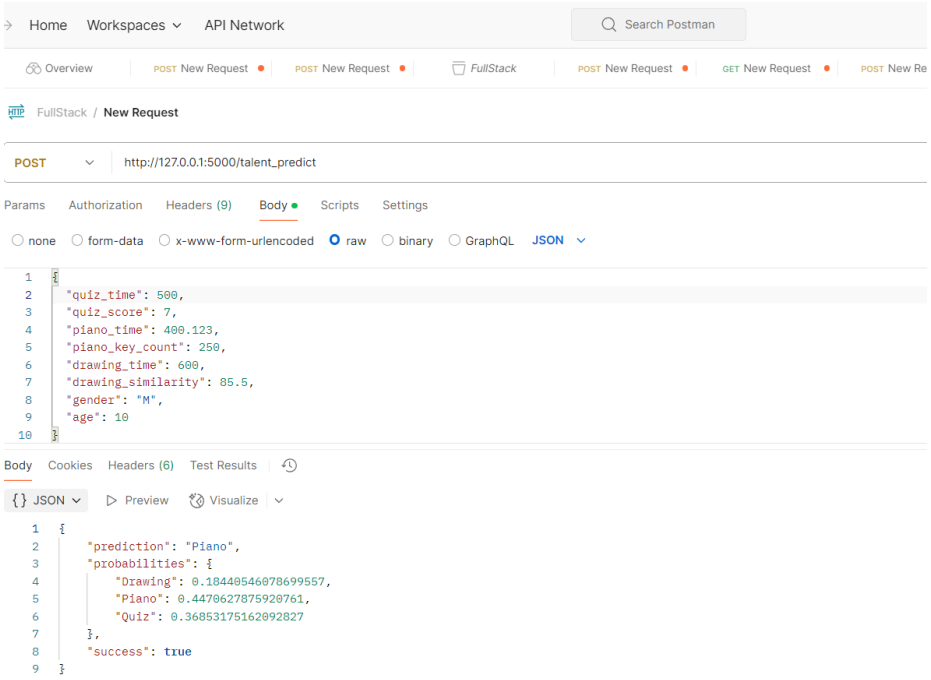


Figure 20 validation of talented area prediction

2.7 Commercialization Plan

1. Market Analysis

Target Audience:

- Children with down syndrome age 5-15
- Parents, caregivers and schoolteachers
- Health care professionals working with children with special needs

Market Size and Trends:

- Increasing awareness and demand for individualized educational help for children with special needs and increasing adoption of technology in the learning process, especially in special education

2. Revenue Model

1. Freemium Model:
    - Offer a free, basic version of the system, with reduced features.
2. Subscription-Based Model:
    - Users could have a subscription service on a monthly or annual basis for parents and institutions and have tiered pricing based on features/levels of access (basic, premium)
3. Institutional Sales:
    - Partner with schools and educational institutions by offering bulk subscriptions.

3. Packages and features

1. Basic Plan

- Features:
    - ✓ Access to cognitive level assessment tools
    - ✓ Basic communication skill improvement activities
    - ✓ Limited personalized quizzes for math skills
    - ✓ Access to painting and piano platforms to develop creativity
    - ✓ Basic summary reports for parents with scores and spent time
- Price: Free

2. Premium Plan

- Features:
    - ✓ All features from the Basic Plan
    - ✓ Advanced cognitive assessment with detailed symptom analysis
    - ✓ Full access to personalized quizzes with adaptive difficulty
    - ✓ Emotion-based engagement activities and mood detection
    - ✓ Advanced summary reports with performance improvement statistics.
    - ✓ Priority customer support.

- Price: $10 per month

3.School/Institution Plan

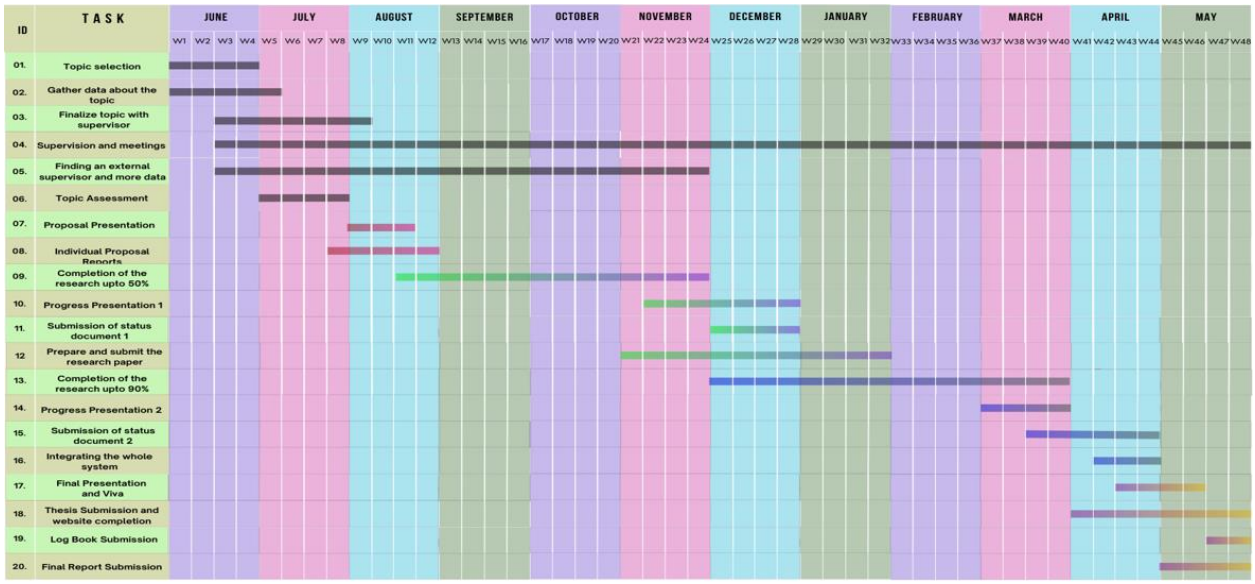
- Features:
  - ✓ Bulk subscriptions with discounts for schools and educational institutions.
  - ✓ Access up to 40 students.
  - ✓ Full access to all features for multiple users [Students].
  - ✓ Training and support for educators to include it in the curriculum.
  - ✓ Detailed analytics and reports for educators on student progress

Price: $30 per month

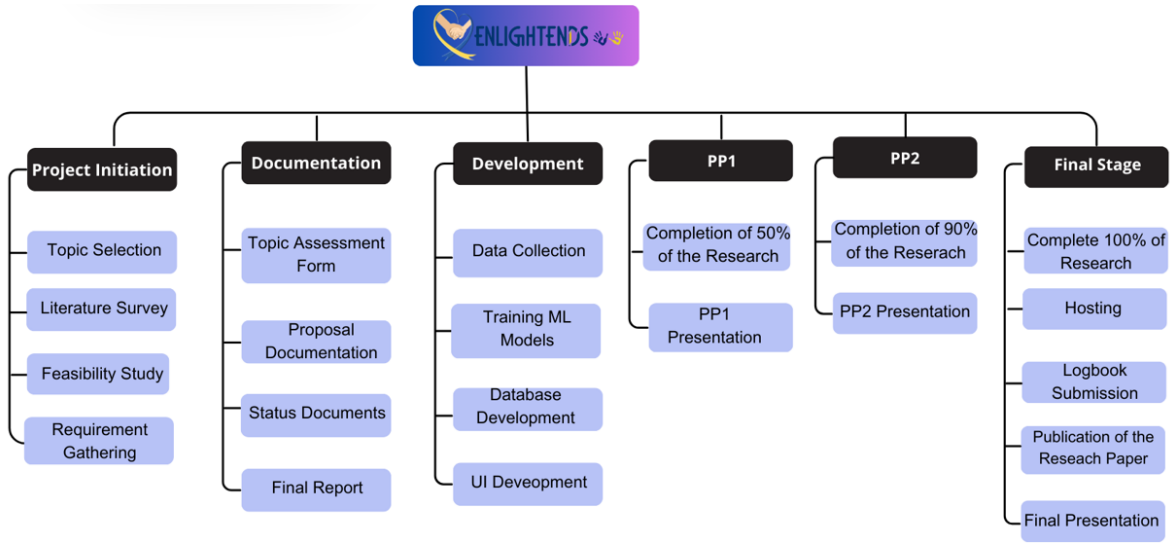
2.8 Budget

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

2.9 Gantt Chart



2.10 WBS



2.11 Test Cases.

Test case ID: Test_01				
Test title: Validate successful navigation.				
Test priority (High/Medium/Low): High				
Module name: Talent identification				
Description: User Should be able to navigate to talent identification page.				
Pre-conditions: User should have valid credentials to login to the system.				
Test ID	**Test Steps**	**Expected Output**	**Actual Output**	**Result (Pass/Fail)**
Test_01	1. User login to the system with valid credential. 2. User should be able to navigate to the talent identification page.	• Successfully user login to the system and once user selected the talent identification page through navigation panel and navigate to that page.	• Successfully user login to the system and once user selected the talent identification page through navigation panel and navigate to that page.	Pass

Table 2 Test case 1

Test case ID: Test_02				
Test title: Validate the learning category selection.				
Test priority (High/Medium/Low): High				
Module name: Talent identification				
Description: Once user selected the quiz category, quiz should display to user.				
Pre-conditions: User should be a valid user.				
Test ID	**Test Steps**	**Expected Output**	**Actual Output**	**Result (Pass/Fail)**
Test_02	1. Login to the system with valid credential. 2. Then navigate to talent identification	• Login should be successful. • User successfully navigated to the talent	• Login should be successful. • User successfully navigated to the talent	Pass

	page. 3. Select learning category.	identification page. • Once user selected the learning category, user should receive a quiz.	identification page. • Once user selected the learning category, user should receive a quiz.	

Table 3 Test case 2

Test case ID: Test_03				
Test title: Validate score calculation.				
Test priority (High/Medium/Low): High				
Module name: Talent identification				
Description: Score calculation				
Pre-conditions: User should successfully login to the system, navigate to talent identification page and selected learning category. .				
Test ID	**Test Steps**	**Expected Output**	**Actual Output**	**Result (Pass/Fail)**
Test_03	1. Once user selected the learning category, user should receive the quiz. 2. Then user completed the quiz.	• Once user receive the quiz, user should be able to select answers. • Once it completed score should display.	• Once user receive the quiz, user should be able to select answers. • Once it completed score should display.	Pass

Table 4 Test case 3

Test case ID: Test_04				
Test title: Validate recital category selection.				
Test priority (High/Medium/Low): High				
Module name: Talent identification				
Description: Validate user navigation to recital category and validate recital functionality.				
Pre-conditions: User should successfully login to the system and navigate to talent identification page.				
Test ID	**Test Steps**	**Expected Output**	**Actual Output**	**Result (Pass/Fail)**
Test_04	1. User should be in the talent identification page. 2. User select the recital category.	• Once user selected the recital category, user should navigate to recital page, • Then user should view a piano. • And user should be able to recital the piano.	• Once user selected the recital category, user should navigate to recital page, • Then user should view a piano. • And user should be able to recital the piano.	Pass

Table 5 Test case 4

3. RESULT AND DISCUSSION

Results

The result of this implementation is down syndrome children can engage with their most interested and talented area. Also, from the feedback notification which will be received to parents will help to identify their children's talents and then they can engage their children's interested area.

From the below attractive and user-friendly UI, user able to select their interested category. Based on the selection they can continue the engagement.

Figure 21 main menu of talent identification page

From figure 23 and 24 represents drawing platform related completed UI and the databased details which are saved. Using the frontend UI user can do the drawing using different colors, erase the drawing and change the blusher size. Not only that but also image similarity comparison and saving functionalities are available. These platform provide user-friendly and entertainable platform to down syndrome children.

This is required to do the accurate analyzation and to identify the exact talented area.

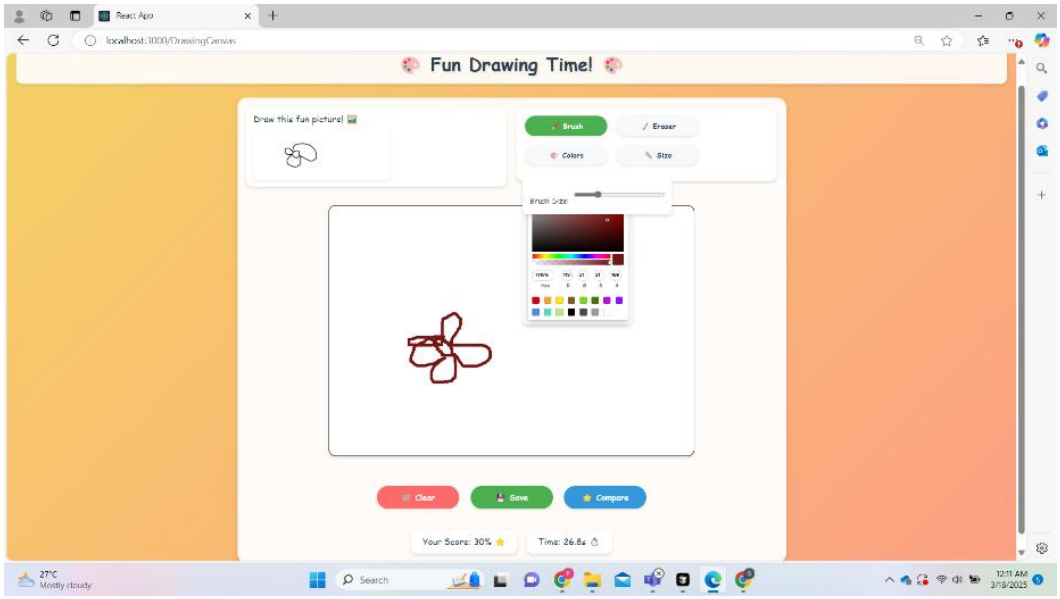


Figure 22 drawing platform

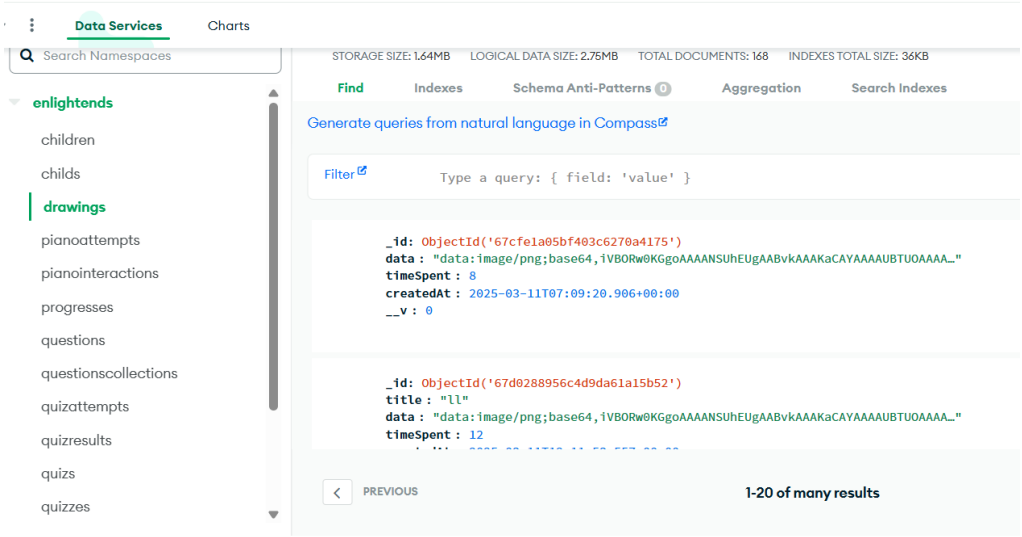


Figure 23 drawing related stored data in the database

Below screenshots represents the UIs and database details which implemented to quiz category. This category implanted using AI. And it always generates random and new questions for new quiz selection. Then users can get more knowledge from this category. Not only that user can re-visit previously attended quizzes.

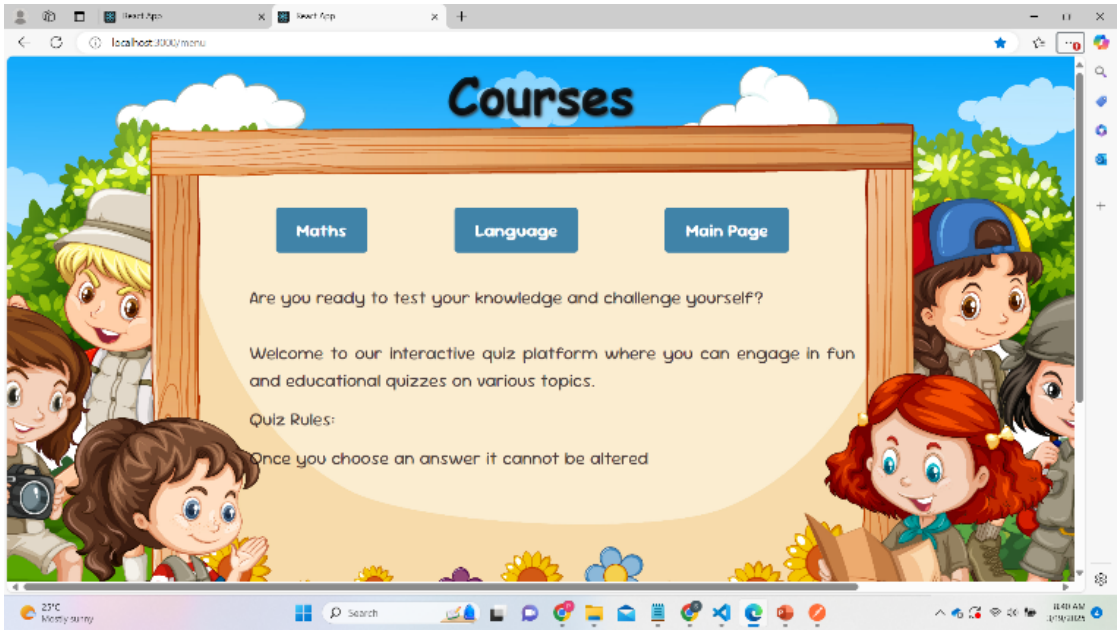


Figure 24 main quiz category page

Figure 25 Quiz collection UI

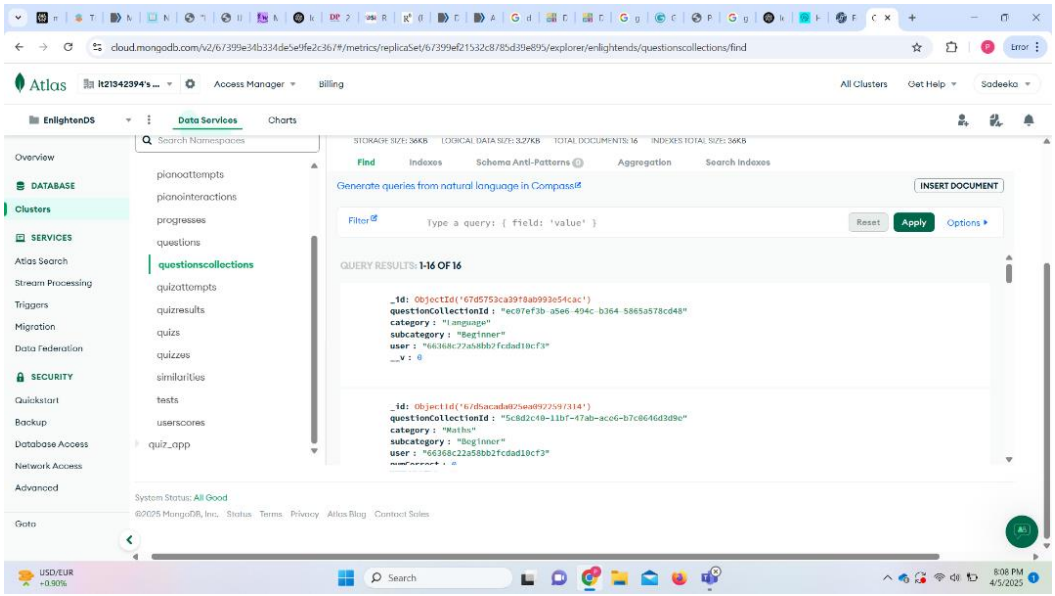


Figure 26 Quiz category related stored data in the database

Figure 27 Quiz summary detail page

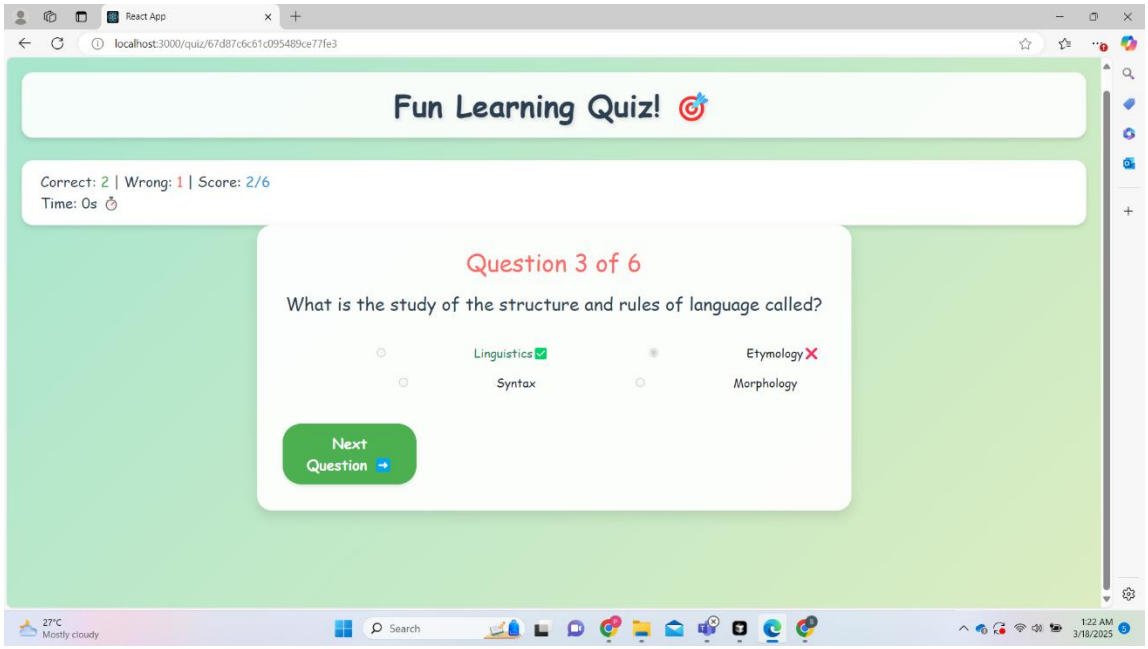


Figure 28 interface which received with question

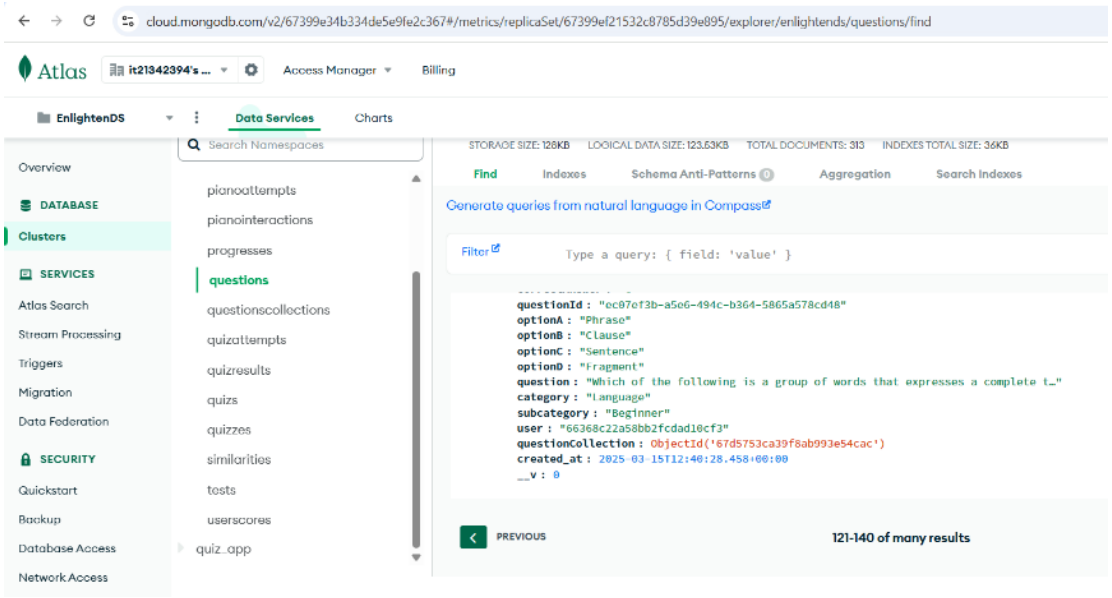


Figure 29 Historical questions related stored data in the database

Below figure 31 and 32 represent piano UI and analyzation related data included database. This piano UI implemented in a attractive and user friendly manner. This will provide interest in down syndrome children to engage.

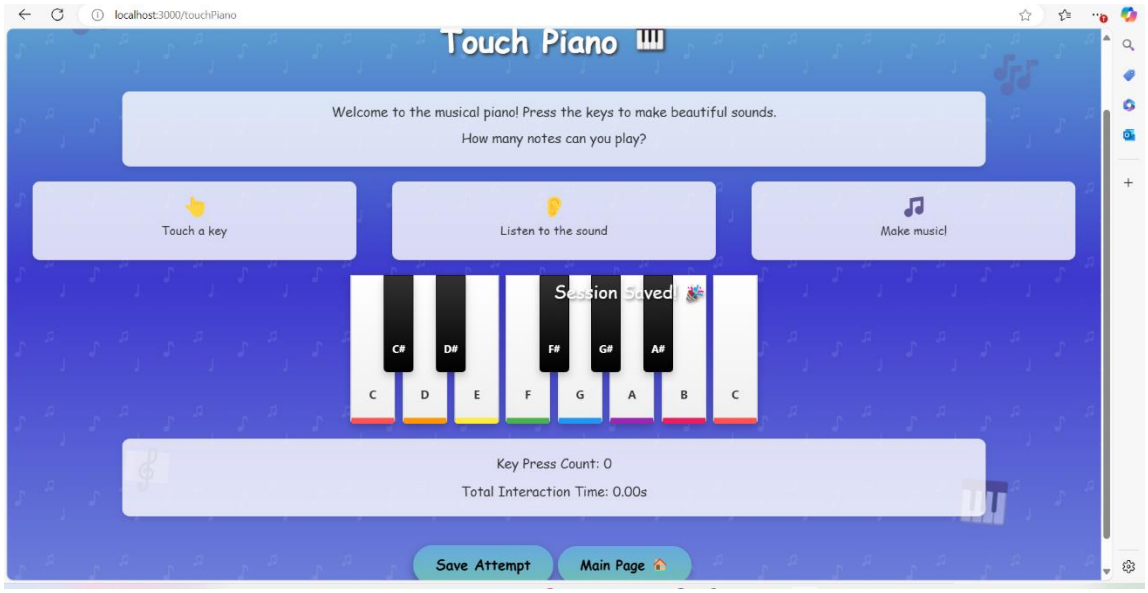


Figure 30Piano platform

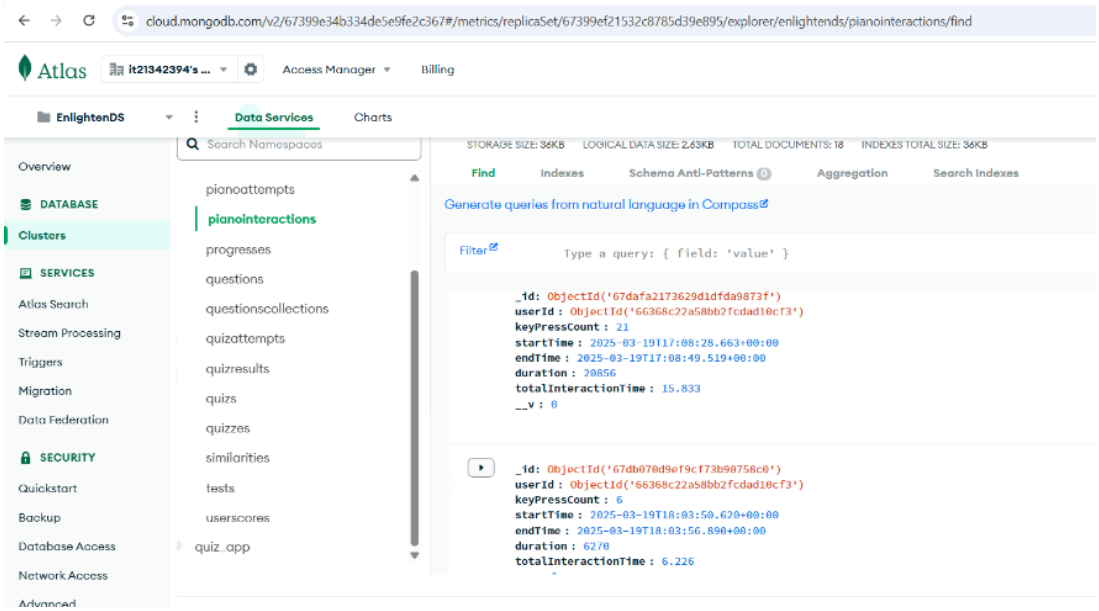


Figure 31 Piano related analyzation details stored data

Research Findings

The main goal of this project was to design and implement a system that can help identify the most talented area learning, drawing, or recital of children with Down syndrome, using interactive platforms built with the MERN stack. After developing and testing the system with the designed logic and dataset, several key findings were observed.

The **quiz platform** successfully measured the learning ability of the users by generating AI-based language-related questions across beginner, intermediate, and advanced levels. It was found that when users scored more than 3 out of 5 questions and completed the quiz within 5 to 20 minutes, they were more likely to be categorized under the learning talent category. The AI-generated questions ensured variety, making each quiz unique and more engaging for the users.

The **piano platform** effectively evaluated motor and recital skills based on finger movement. Analysis showed that if a child interacted with the piano for at least 5 minutes and maintained the required key press range based on the time frame, they were more likely to be considered talented in the recital area. Most successful attempts fell within the 6 to 10-minute range, where key press counts between 200 and 450 showed better consistency.

In the **drawing platform**, many users were able to achieve over 60% drawing similarity within the 5 to 30-minute interaction window, indicating talent in artistic expression. The OpenAI-powered visual comparison method provided an accurate and fair assessment of the drawing's similarity with the reference image. Features like color palette, brush size adjustment, and eraser also helped improve user experience and encourage more creativity.

All interaction data such as quiz scores, drawing similarity scores, key presses, and time spent—were saved to MongoDB and used for further analysis. A machine learning model was trained using a Random Forest algorithm with columns like quiz_time, drawing_time, piano_time, similarity score, key press count, efficiencies, gender, and age. The model achieved a good accuracy, which is a strong starting point for predicting a child’s most talented area.

Another interesting finding was that some users demonstrated potential in **multiple areas**, meaning a child could be talented in both drawing and recital, or in all three categories. This highlights the importance of offering varied platforms to uncover hidden abilities, rather than focusing on a single skill.

Overall, the system proved to be an effective solution for identifying and analyzing the talents of children with Down syndrome. The findings support that interactive, tech-enabled tools can provide valuable insights into a child’s strengths, helping parents, educators, and therapists offer better, personalized support.

Discussion

In this research, a comprehensive talent identification system was successfully developed for children with Down syndrome aged 5 to 15 years using the MERN stack. The system effectively covered three key skill areas: learning skills through an AI-powered quiz platform, motor skills via an interactive piano platform, and drawing skills through a dedicated art platform. Each component was carefully designed to track specific parameters such as time taken, accuracy, key-press frequency, and drawing similarity, providing meaningful data to evaluate the children's strengths accurately.

The integration of artificial intelligence significantly enhanced the quiz component by generating new sets of language-based questions dynamically, enabling diverse and adaptive learning experiences. This adaptability was particularly beneficial as it ensured that each quiz attempt remained unique, thereby reducing the possibility of repetitive memorization and genuinely assessing the child's understanding.

The piano platform, powered by the Tone.js library, effectively measured children's motor and recital skills by tracking their interactions, such as the duration of piano play and the count of key presses. The specific criteria established (such as the required number of key presses within defined intervals) were realistic and beneficial in reliably determining motor skills capability. Similarly, the drawing platform's advanced features, including visual similarity comparison via OpenAI, eraser, adjustable brush size, and color pallet, provided the children with an engaging and supportive creative environment.

The Random Forest machine learning model, trained using the collected dataset, achieved good accuracy. While this accuracy demonstrates the model’s potential in effectively categorizing children's talents, there remains scope for further improvement.

Several important insights were identified from this research. For instance, some children demonstrated talents across multiple skill areas, highlighting the importance of a multidimensional approach to talent evaluation. Additionally, the clearly defined parameters for identifying talent attempts were effective, but refining them further could help capture more subtle differences in skill levels among participants.

Furthermore, the user experience of these platforms for Down syndrome children can be enhanced by incorporating more accessibility features, such as audio instructions, simplified navigation, and visual supports, to accommodate varying levels of cognitive ability.

In conclusion, the developed system effectively addressed the research gaps identified by previous studies, not only by evaluating but also by actively nurturing the unique talents of children with Down syndrome. Future research should focus on increasing more model accuracy, improving user accessibility, and exploring how sustained interaction with such a system could lead to measurable skill improvements among these children.

4. CONCLUSION

This research focused on developing an effective and interactive system using the MERN stack to identify and evaluate the special talents of children with Down syndrome aged between 5 and 15 years. The designed system included three main interactive platforms: a quiz platform to assess learning skills related to languages, a piano platform leveraging motor skills to evaluate recital capabilities, and a drawing platform to determine artistic abilities. Each component captured critical interaction data, such as response time, accuracy, key presses, and drawing similarity scores, storing them in MongoDB for further analysis.

Advanced technologies were integrated into the project; AI-generated questions ensured variety and adaptability in the quiz component, while the piano functionality used the Tone.js library for realistic sound simulation. Additionally, OpenAI's visual comparison technology was effectively employed to measure drawing similarity scores. These platforms provided a structured approach to clearly defining and recognizing talent attempts based on predetermined success criteria.

A Random Forest machine learning model was trained using data collected from all three activities, considering features like quiz duration, piano interaction time, key counts, drawing similarity, gender, and age. The model achieved a good accuracy, enabling it to reliably predict and highlight the child's most talented area among learning, piano playing, and drawing.

This study effectively addressed gaps identified in prior research by not only evaluating the talents of children with Down syndrome but also creating a practical solution to nurture and refine these talents. The developed system helps educators and caregivers better understand the unique strengths of each child, providing tailored support that enhances their developmental potential. Future research may further refine the accuracy of the predictive model by incorporating larger datasets and exploring additional performance metrics, ultimately offering even deeper insights into the individual talents of children with Down syndrome.

5. REFERENCES

[1] CDC, “Down Syndrome,” Birth Defects. Accessed: Apr. 05, 2025. [Online]. Available: https://www.cdc.gov/birth-defects/about/down-syndrome.html

[2]. National Down Syndrome Society (NDSS). (2023). "Health and wellness." Retrieved from NDSS Website.

[3]. de Graaf, G., Buckley, F., & Skotko, B. G. (2022). "Estimates of the population of people with Down syndrome in the United States." American Journal of Medical Genetics Part A, 188(1), 140-147.

[4] World Health Organization (WHO). (2023). "Down syndrome." Retrieved from WHO Website.

[5]. Buckley, S. (2021). "Teaching children with Down syndrome: A guide for parents and professionals." Down Syndrome Education International.

[6]. Al-Rousan, M., & Al-Saleem, B. (2020). "The effectiveness of using multimedia in teaching mathematics to children with Down syndrome." Journal of Educational Technology & Society, 23(1), 30-41.

[7]. Smith, M., & Belcher, H. M. (2020). "Multimedia learning tools for children with Down syndrome: Addressing unique educational needs." Journal of Special Education Technology, 35(3), 135-145.

[8]. S. Buckley, “Creative arts, imagination and expression - An important way of being, sharing and feeling?,” *Down Syndrome News and Update*, vol. 4, no. 3, pp. 77–77, Jan. 2005, doi: 10.3104/practice.334.

[9]. J. B. Janier, A. Shafie, M. F. Taha, N. Bt. Mohamad, W. F. Wan Ahmad, and R. L. Yussof, “Need Analysis for Down Syndrome Children to Develop a Learning Material on Numbers with the Aid of Multimedia Technology,” *IJSSH*, vol. 5, no. 1, pp. 107–111, 2015, doi: 10.7763/IJSSH.2015.V5.433.

[10].A. W. Needham, E. L. Nelson, A. D. Short, L. A. Daunhauer, and D. J. Fidler, “Chapter Four - The emergence of fine motor skills in children with Down syndrome,” in *International Review of Research in Developmental Disabilities*, vol. 60, R. M. Hodapp and D. J. Fidler, Eds., Academic Press, 2021, pp. 113–151. doi: 10.1016/bs.irrdd.2021.08.002.

[11]. A. S. T. Sampath, M. W. Vidanapathirana, T. B. A. Gunawardana, P. W. H. Sandeepani, L. H. S. S. Chandrasiri, and B. Attanayaka, “E-Learning Education System For Children With Down Syndrome,” in *2022 IEEE 10th Region 10 Humanitarian Technology Conference (R10-HTC)*, Sep. 2022, pp. 450–455. doi: 10.1109/R10-HTC54060.2022.9929446.

[12]. H. Hickman, P. McKeown, and T. Bell, “Beyond Question Shuffling: Randomization Techniques in Programming Assessment,” in *2023 IEEE Frontiers in Education Conference (FIE)*, Oct. 2023, pp. 1–9. doi: 10.1109/FIE58773.2023.10342976.

[13]. J. Svendsen, A. B. Albu, and N. Virji-Babul, “Analysis of patterns of motor behavior in gamers with down syndrome,” in *CVPR 2011 WORKSHOPS*, Jun. 2011, pp. 1–6. doi: 10.1109/CVPRW.2011.5981673.

[14]. J. Jadan-Guerrero, L. A. Guerrero, and T. Sharma, “Improving the interaction of Down syndrome students through the use of RFID technology”.

[15]J. Vidanaralage, A. Dharmaratne, and S. Haque, “Schema and emotion in memory retrieval following video-based learning: An artificial intelligence study,” *Australasian Journal of Educational Technology*, vol. 38, no. 5, Art. no. 5, Aug. 2022, doi: 10.14742/ajet.7473.

[16]“(PDF) An Evaluation of Fine and Gross Motor Skills in Adolescents with Down Syndromes,” *ResearchGate*, Oct. 2024, doi: 10.14486/IntJSCS509.

[17]J. S. M. Ong and N. Yahaya, “Using Multimedia Learning Objects in Special Needs Classroom,” *EPESS*, vol. 26, pp. 28–33, Dec. 2022, doi: 10.55549/epess.1196827.

6. APPENDICES

Survey Link - *https://forms.gle/QAtP4zw7gkEtuYQ47*

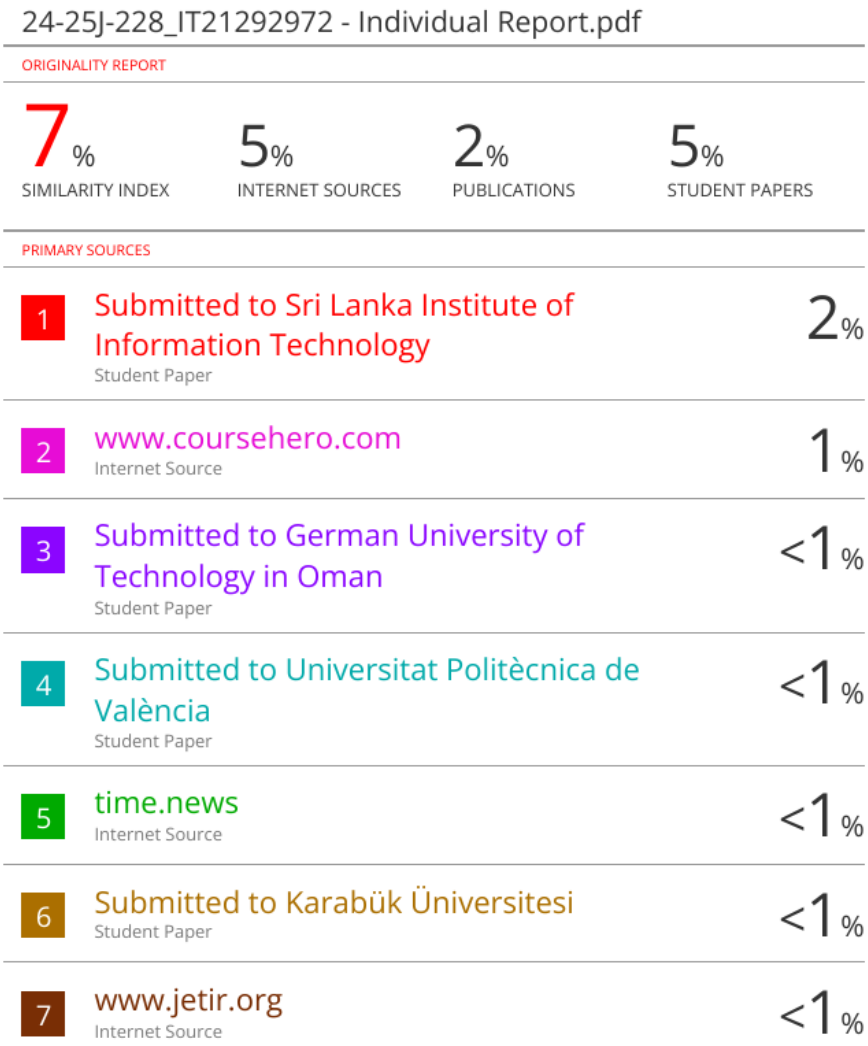


Figure 32 Plagiarism Report