# ALIZA: SMART MIRROR AS AUTISTIC EDUCATION ASSISTANT

2020-079

Project Proposal Report

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## DECLARATION OF THE CANDIDATE & SUPERVISOR

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

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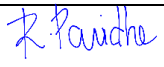
| R.S.Najeeb | IT17137560 |  |
| Uthayan.J | IT17035040 |  |
| R.P.Lojini | IT17131216 |  |
| G.Vishaliney | IT17421768 |  |

The supervisor/s should certify the proposal report with the following declaration.
The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date:

# ABSTRACT

Statistics show an annual increase of the disease about 1 child of 59 in 2018 has with Autism in world in comparison of 1 child of 1000 in 1970 [1]. When considering children with autism, some autistic children struggle with learning basic education skills. It is a challenge to interact and teach with them. Therefore important to help autistic children to develop their education with the help of modern technologies. Recently, there have been considerable advances in the research on innovative technologies for the education of people with autism [2]. There are many different types of smart assistants and devices such as virtual assistants, hundreds of smart-phone apps, wearable and humanoid robots developed for help support individuals with autism day to day activities and educate.

Aim of this research is to develop a smart mirror is known as "Aliza" virtual assistant that interact with autistic children as a voice-based assistant. "Aliza" will be helped to autistic children in their education and learning habits. “Aliza” consist 4 subsystems such as Writing Mentor, Basic Math Tutor, and Voice Assistant and Attentiveness tracker. Sub systems have ability to teach pre-writing skill, basic math and speech trainings. Also, has the ability of determining the child's every single move is monitored through a camera, which analyses their focus in order to teach in an interesting and interactive way. Additionally, it includes a functionality of evaluation the user will be constantly monitored and evaluated during their training by Deep Learning technology.

Through this research we are expecting to improve autistic children's writing skills, basic math skills and verbal skills. Outcome of this research can be improve autistic children’s education skills with the help of "Aliza".



Key words: Aliza, Basic Math Tutor, Writing Mentor, Voice Assistant, Attentiveness tracker, Autistic children

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# 1. Introduction

## 1.1 Background

ASD or else commonly known as Autism spectrum disorder. "One in 160 children has an autism spectrum disorder" (ASD) [7]. This is a common issue in the globe that affects all children. These children should be taken care as they have special needs and should be assisted in daily activities. These children have strength and weaknesses that are common as well as unique to each individual. Mainly there are 3 levels of ASD [8]. Level 1 – commonly has issues with socializing with peers and others, Level 2 – lack of verbal and nonverbal communication and need assistance for tasks, Level 3 – severe communication skills, have distracting behaviors and need constant assistance. Even though they have weaknesses as such they tend to be very organized and work according to a routine. Guided with simple actions and commands helps them easy to complete a given task.

Educating ASD children has to be done in a methodical way that they could understand and level up. They deviate from the methods that is used for non-autistic kids and therapies are given for all basic education. Considering writing skills first they need to be prepped with pre-writing skills. Such as drawing shapes with lines and curves. It is also done in a step by method starting by connecting dots to complete shapes, lines, curves and patterns. Gradually then based on the shapes, lines and curves letters are taught to be written.

Same as Alphabets the numeric are also initially started with prewriting skills as mentioned above. However, when it comes to math skills there are many symbols that makes children critical to learn. And solving math problem always doesn't occur in the same left to right order. Thus, basic training begins with counting numbers with flash cards, count sequentially, find the missing number etc. Since ASD children have a great way of understanding things visually their problem-solving are different compared to a non-autistic individual.

The surrounding is the key element when educating ASD children because they tend to get distract very easily since they are very sensitive to the background environment and reacts for even small changes. Due to this factor gestures are uses when teaching them. Pointing at an object and describing it or illustrating a shape and teaching it are some common teaching techniques. When using gestures, it is common that they repeat the same action and learn by themselves.

Sound is a major factor for ASD children as mentioned above sound does distract ASD children but even use of sound can be utilized for their learning. Clapping hands makes them cherish and enthusiastic that make them want it more. So, mentors use this technique to encourage them in completing activities, to encourage them when they perform well and importantly as an achievement award when they engage in good habits. Moreover, positive reinforcement by words also helps them to learn better.

These therapies are succeeded when an ASD individual reacts upon it and has a continuing improvement. This is measured by their reaction towards these therapies. When a autistic child enjoys the activity they are involved even though they are unable to verbally communicate it they express it by emotions. Emotions play a great deal of importance in them. Sensory Integration Therapy (SIT) [9] explains how to teach ASD students based on their reactions.

Reflecting all factors above this study proposes a smart mirror which caters aspects and provides a smart solution based on machine learning technology. This is an interactive IOT device for ASD children for fun learning.

### 1.2 Literature survey

According to the analysis only few researches have been made on educating students with autistic spectrum disorder using information technology. Developing new IOT devices aren't the requirement because ASD students have motor skills problems, lack of communication or they are unable to understand simple symbols and equations. When implementing an IOT device for ASD student we should understand an ASD student's strength, weakness, skills, knowledge and other main factors. This won't be much profitable too. Until now only few people who really care about ASD children have come forward to invent systems that helps those children to learn.

Acapela group have invented a robot with facial expressions and a screen, which will display the instruction. MILO's functionalities are turn-on emotions, join attentions, speaking activities, improve social behaviours and imitations. MILO is more like a peer who will always keep interacting with the ASD child. Only humans will get bored or feel lazy to do things repetitively, but milo is a robot that doesn't have any feelings such as laziness or tired so it will always keep interacting with the student with recurring positive enforcement [10]. The objective of the robot is to develop social and behaviour skills by continuously encouraging positivity for the ASD student.

A British group of study analysed how autistic group of children react to their own reflection in a mirror. Whether they identify themselves on the mirror and socially interacting with them (try to speak with the reflection, showing any actions to see the image to react), and are they using the mirror to see things behind them. The methodology is to paste a sticker on the mirror covering their faces and record and analyse the difference after removing the stickers. And the end of the study they got a group of students who used the mirror to see things behind them and some kept trying to identify the person on the mirror [11].

An article published on July 1973 by mark Colby says that "non-speaking autistic children have shown improvement in studying without an adult interference, using keyboards and audio-visual play has the success rate of 13 out of 17" [12]. So, the

conclusion is computerized teaching on language difficulty is more successful than the manual approach.

There are many mobile applications that are out there to help autistic spectrum children in developing social skills, writing numbers and to develop motor skills. Otsimo [13] is a mobile application that help the ASD students to learn numbers, colours and shapes. Match and find is an app with simple activities like matching the same objects given [14].

As per the survey milo robot is the only IOT device that have been developed in considering few aspects of the ASD student. Other applications are less effective than milo because they don't interact with the user. So, make the education better we need a better solution.

### 1.3 Research Gap

As per literature survey we have a basic idea of how computerized system help with educating ASD students. The bigger question is **what's the difference in Aliza?**

Aliza is not a robot or mobile application its smart mirror that have the features which is more advanced than the devices that are being used nowadays. When comparing with MILO robot Aliza doesn't express facial emotions but, will detect what's the current mood of the user and change activity if the user is bored or not paying attention in the session? Even though emotions are not explicitly expressed, implicitly the tone variation expresses emotion and repetitive positive feedback is given. An additional feature motor skill is added into the system to make them have fun physically with the mirror and to improve focus. Also, milo robot doesn't have any evaluation plan to identify the intelligence level of the student whatever the student's stage is it will treat everyone from a basic level. Aliza on the other hand will pre evaluation to evaluate the intelligence level of the student and treat each of them according to their level.

Aliza is a fully automated system that have voice assistance which always guide the student on every process. It's more user friendly so even a child can use it without any adult interaction. Moreover each student will have a separate profile that will be only accessed by the user.

When we compare the math and writing activities between mobile applications and Aliza, we have collected 100s of sample data from randomly selected ASD students and developed the system according to that. In other systems the students do it according to their way of approach but in Aliza even if the student writes anything out of shape we can still figure out what the student have written in the screen. According to their improvement their activities will be levelled up on each stage. These approaches aren't available in any other systems.

Except from other application our system will compare the improvement of the ASD student with a normal child. Generated reports are available to check of each user's improvement until that point. If the ASD student communicates better than before and

independently uses the mirror for activities and complete activities as expected, our objective is been achieved. The Table 1.1 shows the comparison of related works.

| **Product name** | **Type** | **price** | **Pre-evaluation** | **comparison** | **Levelling up** |
|---|---|---|---|---|---|
| **ALIZA** | Smart mirror | moderate | ✓ | ✓ | ✓ |
| **OTSIMO** | Mobile app | less | ✗ | ✗ | ✗ |
| **MATCH AND FIND** | Mobile app | less | ✗ | ✗ | ✗ |
| **MILO** | robot | high | ✗ | ✗ | ✗ |

*Table1.1: Comparison of related works*

### 1.4 Research Problem statement

As far as it has been stated as a statistic by world health organization that "One in 160 children has an autism spectrum disorder (ASD) [3]. ASDs begin in childhood and tend to persist into adolescence and adulthood. While some people with ASD can live independently, others have severe disabilities and require life-long care and support"[4]. This is a major cause in our future generation. Existing tools and mechanisms are insufficient since these methods doesn't cater all the ASD children's educational needs. Parents of these kids hunts for the affordable and efficient therapies, strategies and apps to provide their kids with the ideal solution. However, in the academia and industry new trending technologies such as robotics, Artificial Intelligence, Internet Of Things are introduced but not greatly used for Autism education.

Adolescent age is the greatest age to of learning where [5] 85% of the brain development occurs by the age of 5. So, it is a greatly important to handle all autistic children with proper material and learning application. More innovative solutions must be given to them with diverged technology.

When looking back in the improvement in this sector mobile apps were introduced after manual therapies. Mobile applications had a huge range of activities for children that facilitates autism education bust was not much of an impact on them. Since the screen engagement time was not as much as effective as interacting with a real mentor or with their same aged peers. Therefore, when robots came into play it had a significant impact on children other than the mobile app. But as a massive drawback these equipment's where too expensive to afford. So, the technological advancement was barely a benefit in above scenario.

As the world is more emerging with the concept of making everything "SMART". Smart phones, smart homes, smart cities, smart transportation are a hit currently. Below Figure 1.1 show the overall impact of smart concept

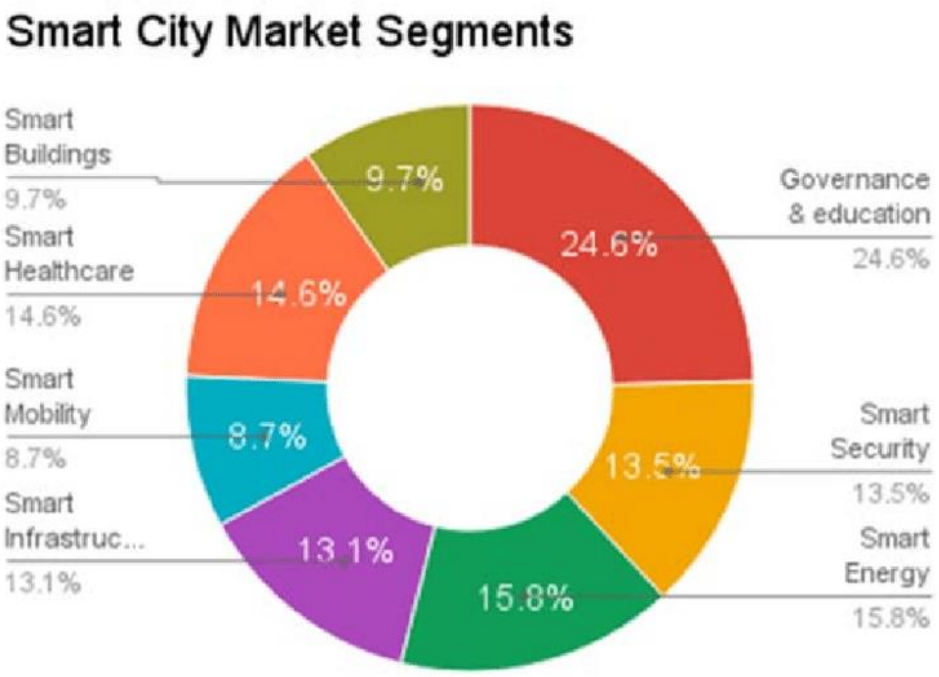


*Figure 1.1: An Overview of the Technology Trends Driving Smart Cities* [7]

Above Figure1.1 illustrates 24% of the education is adapting "smart" concept. So, this is a great phase to introduce smart equipment's to the ASD children. This research study proposes an innovative approach for autistic children; a smart mirror "Aliza" as an educational companion to ASD individuals for better learning based on their emotion.

# 2. Objectives

## 2.1 Main Objective

The main objective is to implement a smart mirror that helps to improving the writing skills, basic mathematical skills, verbal skills and focusing skills of ASD children. Also, accustoming modern technology learning system among the ASD children.

## 2.2 Specific Objectives

1) Increasing the overall quality and knowledge of the ASD children's pre-writing
   skills through using Aliza-Writing Mentor system.
2) Increasing the basic mathematics skills of the ASD children through using Aliza- Basic Math Tutor system.
3) Increasing the verbal skills of the ASD children through using Aliza- Voice Assistant system.
4) Improving activity's focus based on tracing ASD children's behavior and emotions using Aliza- Attentiveness tracker system.
5) Improving few peer socialization among the ASD children' after using the "Aliza"
6) Adapting users for smart home concept.

# 3. Methodology

## 3.1 Data Collection

Proposed system needs collection of word utterance, image data of child's day to day normal written work such as line, curves, shapes drawing and number writing. Required data is going to be taken from randomly selected 100 ASD children from 5 selected schools in Colombo and Jaffna districts. To obtain the word utterance of ASD children, it is planned to place a voice recorder within their pocket or within a close distance to them. ASD children will be given a task in between their learning session to write by their own inside a fixed writing space to obtain the image data for written work. Data for facial reaction recognition system will be obtained from public data archive.

## 3.2 System Architecture

High level architecture diagram of Aliza is shown in figure 3.1.

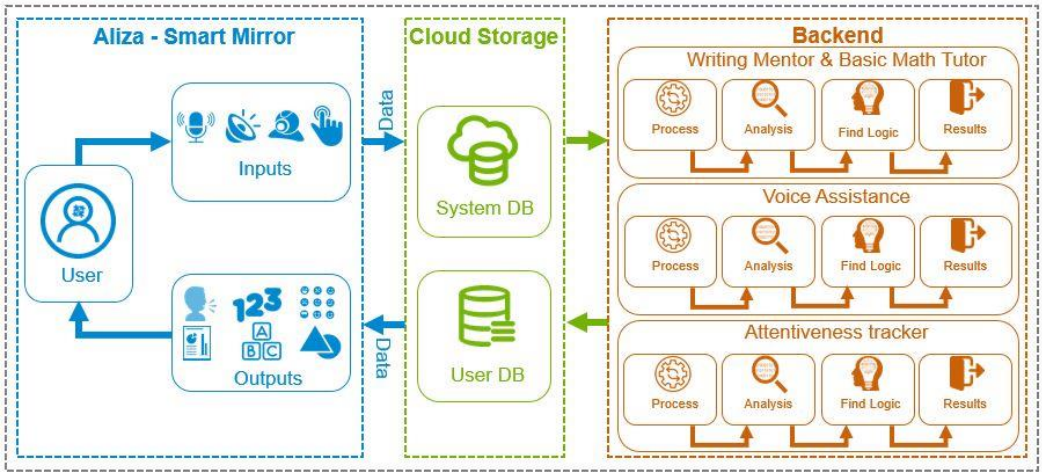


*Figure 3.1 – High-level architecture diagram*

### 3.2.1 Hardware solution

As shown in Figure 3.2, IR overlay frame is on top of the mirror, LCD monitor on the bottom, covered with a wooden frame to hold them together.IR overlay frame adds touch to the system while the LCD monitor is to display the program. These three aesthetic components are estimated to be in 40 inches so that the kid can have enough space to interact. Raspberry Pi is the brain of smart mirror. It is a powerful tool for Artificial intelligence and machine learning. It has the processing capability with low

processing power. A speaker and microphone is connected for voice recognition and a webcam is connected with monitor for facial recognition system.

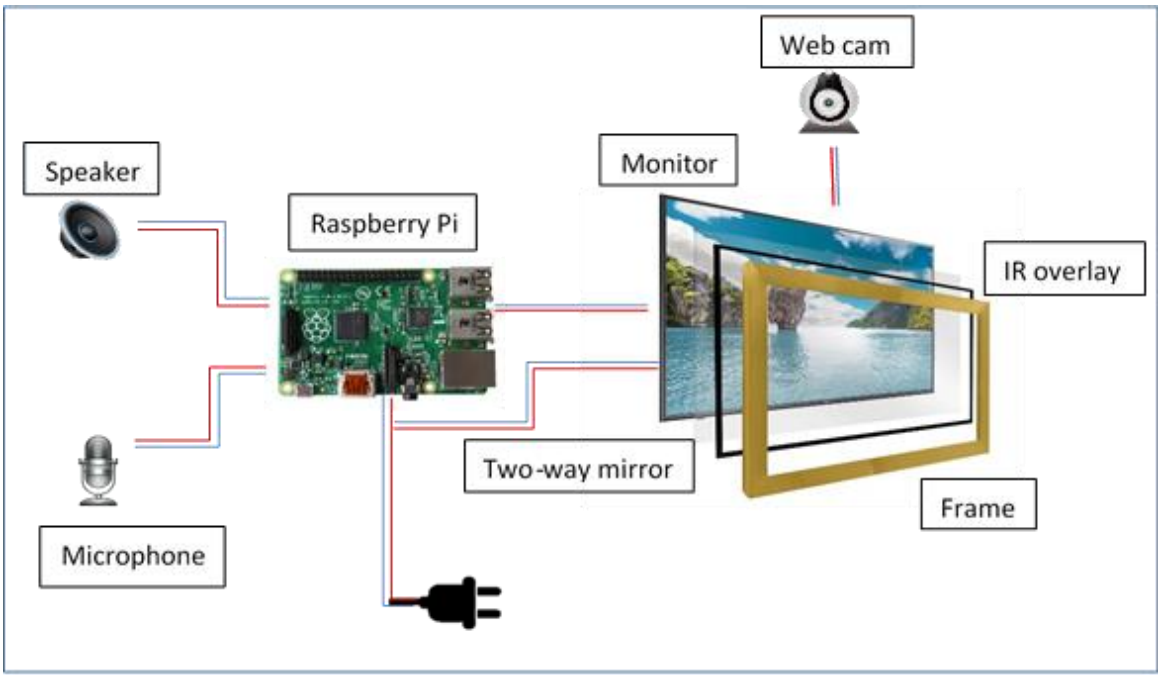


*Figure 3.1 – Hardware Architecture diagram*

### 3.2.2 Software Solution

The proposed "Aliza" has the core components of

1. Writing mentor – to teach pre-writing skills
2. Basic math tutor – to teach numeric and basic math.
3. Voice assistant with verbal trainer – to interact through voice and improve speaking skills
4. Attentiveness tracker – to monitor the child's attentiveness throughout the activity.

- **Writing mentor**

  This study is going to get primary data about randomly selected 100 ASD children between the ages of 5 to 12 from 5 selected schools in Colombo and Jaffna districts. Gathered image data will be fitted into 28x28 pixel images and black and white images are converted to gray scale by anti-aliasing technique during the normalization process. Writing mentor provides pre-writing activity games based

on tracing and dot strategy. Through this strategy ASD children can easily able to develop their pre-writing skills [15]. This component begins with a pre-evaluation process where the child has to write letters or draw shapes independently, to find out their level.

Activities will be provided based on their level and end of each level, an evaluation test will be given to level up them. Seven-layered CNN strategy is used to identify the input image taken in the evaluation stage. This strategy can identify the input image and produce the percentage which is consistent with ideal image.

- **Basic math tutor**

  The process start from a pre-evaluation activity, When the user write something on the screen the system will convert the number in to a 28 * 28 pixel image. Using CNN algorithm number's each edges will be allocated to the neurons according to it pixel darkness. For white neuron will represent 0 and for black is 1. The neuron will have any amount between 0-1. then using hidden layers the pixel will be multiplied with the weight of the connection, at the end which number correspond with the weight of the neuron will be taken as the number on the screen. Through this process we can identify any number which written slightly, shapeless, and curvy.

  After the pre- evaluation each student have to follow the activities according to their intelligence level. When they have completed a level successfully their difficulty of the activities will increase. At the end ASD student's improvement will be compared with a normal student, if they have match the level then our goal is been achieved or else the student have to try the process until they match with a normal student.

- **Voice assistant with verbal trainer**

  This component facilitates the user to choose the activity by voice or tapping on icons of choices. While the attentiveness tracker monitors the facial reaction, voice assistant analyzes the processed data and prompt the user to swap to another

activity if they are less engaged to the system. Two types of activities are given. One is choice based activity where the child has to tap on the correct answer which is a picture card. The system will read aloud the word and the kid is encouraged to repeat the word. Other activity is to find the objects in given picture.

Audio data taken from these activities will be the input for the activities. Background noise in the recorder audio file should be removed first. Audio data needs to be converted to speech signal by finite number of measures which is called as feature extraction. MFCC (Mel-Frequency Cepstral Coefficients) will be used for feature extraction. There are different approaches to recognize the word and evaluate whether the child has correctly pronounced the word such as audio finger printing, HMM (Hidden Markov Model) and AAN (Artificial Neural Network) and the best fit has to be decided.

- **Attentiveness tracker**

The data collection is done by collecting data from public data archives which contains randomly selected approximately 160 students around the age of 2 – 8. Collected data set will be processed to detect the face with Viola-Jones algorithm. It detects the face on gray-scale mode then find the actual location in the colored image [16]. Then normalization process is done. Active shape model is the most ideal technique for detection and tracking of triangulation points [17] in the face. For the points detected the location of the image is identified by the gradient of image texture. This extracts the facial emotions of the user.

The motor skills activity is based on dot to dot strategy. The activity starts with a dot and when the user correctly touches the dot then it leads to the next dot in the screen. The evaluation for this activity is based on their response time. To make them more physically moving the dots are appeared all over the mirror to place the dots. This is generally done by optimization. The longest response time taken to the dots will be generated in a pattern using reinforcement learning [18].

## 4. Description of Personal and Facilities

| Member Name | Component | Tasks |
|---|---|---|
| G.Vishaliney | Writing Mentor | • Creating evaluation models and train models.<br>• Creating pre-writing activity's animations and pictures.<br>• Create pre-writing activities and levels.<br>• Evaluating ASD children pre-writing skill levels in each activity.<br>• Leveling up activity levels through the evaluation. |
| J.Uthayan | Basic Math Tutor | • Gather sample data from multiple ASD students.<br>• Convert data from the screen as an image. Evaluation of answers from ASD student s with the actual answer.<br>• Analyzing the improvement of ASD students.<br>• Compare the knowledge improvement of the ASD child with normal child. |
| R.P. Lojini | Voice Assistant | • Implementing a word recognition system to match with pre-defined words.<br>• Analyze progress data of other skill development activities and prompt positive reinforces.<br>• Analyze data from facial reaction and prompt to swap to another activity |

| | | |
|---|---|---|
| R.S. Najeeb | Attentiveness tracker | • Process data of the ASD individual's images.<br>• Train models based on images.<br>• Get necessary data from the sensors camera.<br>• Evaluation models with test data.<br>• Analyze user's facial patterns.<br>• Utilizing the data capturing frequency. |

*Table 4.1: Description of Personal and Facilities*

## 4.1 Work Breakdown Structure (WBS)

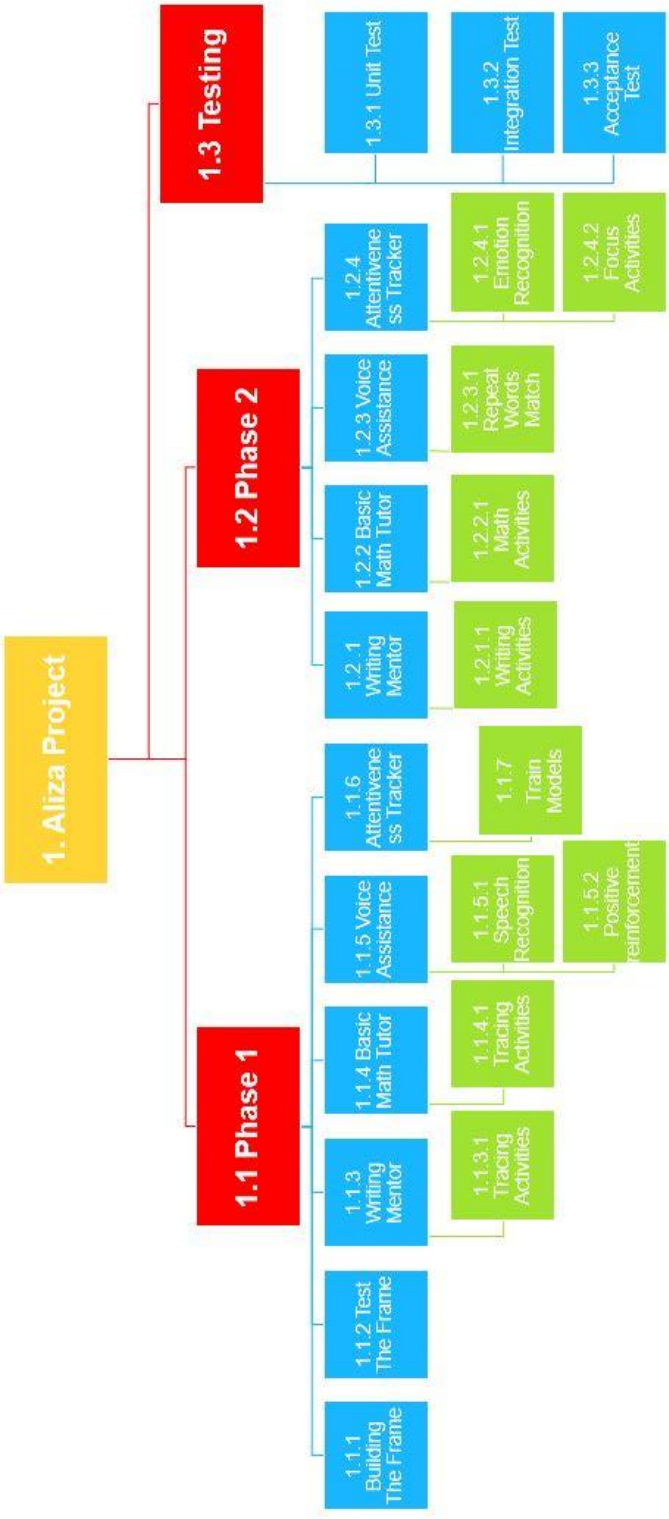


*Figure 4.1: Work Breakdown Structure (WBS)*

# 5. Requirements

## 5.1 Functional Requirements

1) Users being able to create an account.
2) User can choose the activity by voice command.
3) Users can swap through activities (Based on their facial reactions).
4) User should be pre evaluated before a task (Writing Mentor and Basic Math Tutor).
5) System allow user to practice pre-writing tasks through animations teaching style.
6) Students will be able to improve their math knowledge by given activities.
7) System should evaluate whether the user has repeated the word correctly.
8) Prompting positive words to appreciate when an activity is performed well.
9) Users will be able to generate a report of the progress of writing skills.
10) Users will be able to generate a report of the progress of basic math activities.
11) System indicate progress of the user by analyzing how accurate the activity is performed (Voice Assistant).
12) Motor skill enhancing activities provided to enhance attentiveness.

## 5.2 Non-Functional Requirements

1) Usability

   Simple use of language and basic instructions provide for a user friendly system.

2) Affordability

   The system is at an affordable price that can be used for household as well as in schools. Moreover the system facilitates many user accounts through one mirror.

3) Security

   The images of the individuals will only be processed and stored as a result. No individual data will be exposed.

## 7. Budget

Project period: February – December

| Expenditure Description | Budget Requested ($) | Justification for Expenditures |
|---|---|---|
| Wood Frame and Two-way mirror | 5000 | Purchasing this items for smart mirror creation. |
| Raspberry pi | 8000 | |
| IR panel | 20,000 | |
| LCD monitor | 12,000 | |
| USB speaker | 2000 | |
| Microphone | 400 | |
| Power Supply unit | 500 | |
| Camera | 2500 | |
| SD card | 300 | |
| Travelling | 3000 | Travelling cost of for pre-data collection to ADD children's schools |
| Others | 2000 | Printing, photocopy, Internet, Telecommunication |
| **Total** | 55,700 | |

*Table 7.1: Research budget*

## 8. Commercial Value

The commercial value of the proposed solution is increased through below mentioned information:

- The system accommodates many users through one mirror which can be used in schools and homes as well.
- The system provides parents with the facility to easier way to track their child's progress.
- Since the system is wall mounted smart mirror therefore easy to use and attracts many users.
- The system provides the facility to swap game activities by user as per their convenience.
- Especially this smart mirror has a user friendly voice assistant.

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