

Development of an Effective Assessment and Training Support System for Cognitive Ability for Special Children

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Abstract: - In definition, special children include children who are having Down syndrome, autism, global delay, epilepsy, slow learner and others. In this study, the special children are focused on children with Down syndrome. Down syndrome occurs due to an extra copy of chromosome 21 in the children's chromosome. Early intervention Program (EIP) is a systematic program with therapy, exercises, and activities which designed to help children especially special children. Cognitive development is the construction of thought processes, which is one of the most important skills that have to be developed for Down syndrome children in order to lead a normal life. This support system is focused mainly to help them improving their logical thinking and memory skills. This cognitive assessment and training support system utilizes the radio frequency identification (RFID) technology implemented in C Sharp programming language. The completed system was then tested and feedback was obtained from parents or trainers of Down syndrome children. The results show that the system can generate results in graphical form stably and training for improving the cognitive ability of the children is reliable based on global recognized curriculum. In conclusion, the system can be used in order to help trainers or parents to improve the cognitive ability of children with Down syndrome.

Key-Words: - Support system, cognitive ability, special children, RFID, Early Intervention Program, Assessment and Training

1 Introduction

In Down syndrome, 95% of all cases of Down syndrome are caused by one cell that has two 21st chromosomes instead of one, so the resulting fertilized egg has three 21st chromosomes [1]. It is one of the most common genetic birth defects, affecting approximately from one in 600 to one in 1,000 babies [2]. According to National Down Syndrome Society, there are more than 350,000 individuals with Down syndrome in the United States and the chance of a woman having a child with Down syndrome increases as she is getting older [3].

There are about 100 identified characteristics of Down syndrome [4]. People with Down syndrome experience delays of cognitive and physical development, but the effect is usually mild to moderate. There is an extremely wide disparity among people with Down syndrome in the issues of cognitive or developmental delay [5]. However, research has shown

that educational and therapeutic interventions such as early intervention services can greatly benefit learners with Down syndrome. In the other words, supports and early planning are often necessary to facilitate employment and community life.

Although some of the limitations of Down syndrome cannot be overcome, early intervention program is proven to be able to improve quality of their lives [6].

2 Literature Review

2.1 Cognitive assessment

Cognitive assessment is a scientific attempt to study cognition and measure human behavior [7]. Measurement of human behavior involves giving the participant an opportunity to "behave" and measuring it.

A measurement tool should be reliable and valid, sensitive, safe and should offer the assessor full control over the data collection process. Allowing the participant "to behave" involves the presentation of stimuli which trigger recordable reactions by the participant [8]. Many classic, paper-pencil cognitive assessment tests offer very limited stimuli, little freedom to behave and low ecological validity (that is, little relevance to normal, everyday human behavior in the real world) [9].

2.2 Cognitive development

Development is the continuous progressive change in the organism. Psychologists have analyzed it from the different aspects which include physical, mental, social, emotional, and moral development. Mental development means development of perception, memory, imagination, thinking, reasoning intellect, and many modern psychologists call these as cognitive development. Cognitive development is defined as thinking, problem solving, concept understanding; information processing and overall intelligence [10].

Adaptation is the main basis of cognitive development. Jean Piaget states that there are five fundamental stages of cognitive development of a child. The stages are stage of sensory-motor thinking, pre-conceptual stage, and stage of institutive thought, stage of concrete operation, and stage of formal operation. From birth up to the stage of two years is the stage of sensory-motor actions. Sensation caused by sound is a common experience to a child and makes him utilize his power of thinking.

The second stage is called pre-conceptual stage where child can form some pre-concepts based on his past experiences. Pre-conceptual stage takes a complete change with a purpose of placing the base of concepts on solid foundations and making them practical and more expanded. The next stage is called stage of intuitive thought. This stage expands from 4 to 8 years old. The difficulties of thinking which exists at pre-conceptual stage get eliminated and active realistic thoughts develop.

The next stage of cognitive development expands from 8 to 11 years, and this stage is called period of concrete operation. When the children make synthesis in the fundamental thoughts, their active or rational thinking begins. A child, when he reaches at the stage of concrete operation, forms concepts facing realities. The last stage of cognitive development is the period of formal operation which from 11 to 15 years. At this stage, the thoughts of a child are not controlled by his

practical experiences or personal observation but acquire power of abstract thinking.

Table 1
The stages for cognitive development according to Jean Piaget

Stage	Name of stage	Range of age (years)
1	sensory-motor thinking	0-2
2	pre-conceptual	2-4
3	institutive thought	4-8
4	concrete operation	8-11
5	Formal Operation	11-15

2.3 Radio Frequency Identification (RFID)

Radio-Frequency Identification (RFID) is a generic term that is used to describe a system which transmits the identity in the form of a unique serial number wirelessly, using radio waves. This is a technology that allows automatic identification of objects, animals or people by incorporating a small electronic device that consists of a small chip and an antenna. Data is stored on the chip and be "read" by wireless devices, called RFID readers. The chip typically is capable of carrying 2,000 bytes of data or less.

A basic RFID system consists of three components which are an antenna or coil, a transceiver with decoder and a transponder (RF tag) electronically programmed with unique information as shown in Fig. 1. The antenna puts out radio-frequency signals in a relatively short range. The RF radiation does two things which are provides a means of communicating with the transponder (the RFID tag) and provides the RFID tag with the energy to communicate in the case of passive RFID tags. RFID tags do not need to contain batteries, and can remain usable for very long periods of time.

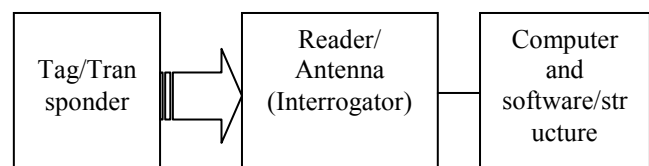


Fig. 1: A basic RFID system

The antenna from the RFID system emits radio signals to activate the tag and to read and write data to it. The RFID reader emits radio waves in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency used. When an

RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

RFID tags divided into two types which are active and passive RFID tags. Active RFID tags have their own power source usually by a battery while the passive RFID tags do not require batteries but it operate using power from the RFID transceiver. The advantage of using active RFID tags is that the reader can be much farther away and still get the signal. Even though some of these devices are built to have up to a 10 year life span, they have limited life spans. Passive RFID tags can be much smaller, inexpensive and have a virtually unlimited life span, but do not have good range. Passive tags typically store between 32 and 128 bits of data and are Read-Only while active tags can store up to 1MB of data and are typically rewritable.

Table 2
Comparison between RFID and barcode

	RFID	Barcode
Direct line of sight	Do not require a direct line of sight to either active RFID tags or passive RFID tags.	- Require a direct line of sight to the printed barcode - Printed barcode must be exposed on the outside of the product.
Range of read	- Can be read at much greater distances. - Pull information from a tag at distances up to 300 feet.	- Range to read is much less. - Pull information no more than fifteen feet.
Read rates	- Much faster. - Read rates of forty or more tags per second are possible.	- More time-consuming. - May take seconds to read an individual tag. - Usually take a half-second or more to

		successfully complete a read.
Read/write	- Can be read/write. - Alter as much of the information as the tag design will allow.	- No read/write. - Cannot add to the information written on a printed barcode.
Price	More expensive.	Cheaper.

2.4 Current research on EIP

Currently, several researches on implementing EIP have been done. For example, another support system to train the language ability has been developed by using the speech recognition technology [11]. Besides that, in order to ensure children activities are observed during training, a face tracking software has been developed by researchers in UTM [12]. Realizing that the confidentiality of the children and parents' information. A medical data security model has also been created to help in the implementation of EIP [13].

In this study, the cognitive ability will be emphasized as compared to other developmental abilities due to the mentioned problem in the status quo previously. Here, we present an interactive support system for cognitive assessment and training for special children. Several aspects for example the age and ability of the children are considered while the assessment and training for cognitive ability is being done. This support system does not only serves as cognitive assessment and training system, but also important in managing the children data effectively and providing scientific information about Down syndrome to parents and trainers.

3. Methodology

The activities in the cognitive module in this support system are chosen from Hawaii and Denver by occupational trainer for special children. This module has been divided into several groups such as perception, concentration, logical thinking and memory. Table 3

shows the groups of activities in cognitive module. This is one of the easier ways for the trainers or parents to give training for the child. By dividing the activities in separate groups, the trainers or parents can recognize where the weakness part of the child is and can give concentration of training to the child.

Table 3
Groups of activities in cognitive module

Group Number	COGNITIVE
33001	PERCEPTION
33002	CONCENTRATION
33003	LOGICAL THINKING
33004	MEMORY

3.1. RFID-based Input Unit

Radio Frequency Identification (RFID) device is part of cognitive ability support system. It is used as the input unit for the computer processing unit. This RFID device can detect or read RFID tags (input) and the data input will be sent to the processing unit to evaluate results such as results for assessment and training of cognitive ability. Fig. 2 shows the type of RFID reader used.



Fig. 2: RFID Reader IDR-232

Reader IDR-232 has been designed with capabilities and features of:

- Low cost solution for reading passive RFID transponder tags.

- 9600 baud RS232 serial interface (output only).
- Fully operation with 5VDC power supply.
- Buzzer as sound indication of activity.
- Bi-color LED for visual indication of activity.
- Standard RS232 serial cable for communication port
- USB power source from laptop.
- 0 - 2 cm reading range.
- 0.1s response time.
- Operating frequency: 125kHz
- RFID tags used : MIFARE card

The connection of the RFID reader must be connecting to desktop/ laptop for power supply and the communication line must be connect to serial port of the computer. After providing power through USB power source, the LED will be in YELLOW color. High level language (Visual C# programming language) which can access to serial port is used to develop program for IDR-232 on the computer.

3.2. Driver for RFID reader

IDR-232 is basically connected to desktop or laptop through communication line. In order to get the input reading of RFID tags, the reader is connected to the Hyper Terminal (software) with appropriate configured settings.

In visual c# implementation, this RFID reader can be connected by a driver in the form of visual c# source code. This driver is called using System.IO.Ports. It is part the loadable device driver interface. Below shows the source code for the connection of RFID reader through Visual c#:

```
public void startRecognition()
{
    tagsActivated = true;
    isTagTrue = new
    Boolean[tagIDNow.Length];
    for (int i = 0; i < isTagTrue.Length; i++)
        isTagTrue[i]=false;
    readTag = "";
    if (serialPort1.IsOpen) serialPort1.Close();
    serialPort1.PortName = "COM6";
    serialPort1.BaudRate = 9600;
    serialPort1.DataBits = 8;
    serialPort1.ReceivedBytesThreshold = 5;
    serialPort1.Open();
    timernow = 0;
```

```

        timer1.Start();
    }
    private void serialPort1_DataReceived(object sender,
        System.IO.Ports.SerialDataReceivedEventArgs e)
    {
        //if read RX = 0 then new card
        RxString = serialPort1.ReadExisting();
        if (RxString.Equals("0"))
        {
            readTag = RxString;
        }
        else
        {
            readTag = RxString;
            if (readTag.Length == 10)
            {
                this.Invoke(new
                    EventHandler(DisplayText));
                readTag = "";
            }
        }
    }
}

```

3.3 System Configuration

In order to train the cognitive ability of special children, a support system for cognitive assessment and training is developed by using the C Sharp programming language in Visual Studio together with the implementation of Radio Frequency Identification (RFID) technology in the program. The database of the support system is easily updated and reliable as it follows the standards of internationally recognized curriculum.

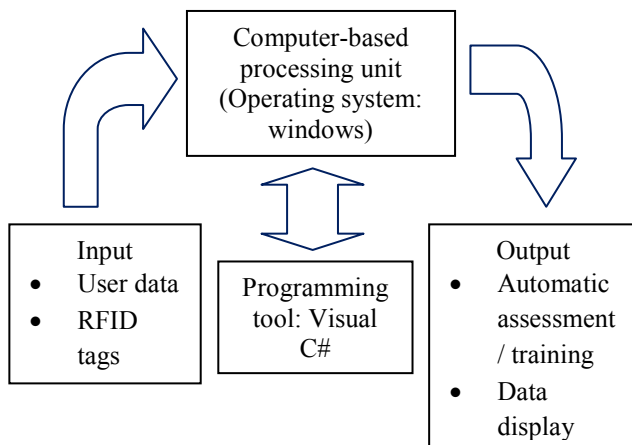


Fig. 3 Block diagram of the support system.

According to the block diagram in Fig. 3, the data is inputted into system by user or RFID tags. Then, the program will read the inputs and produce the output and displayed through GUI application.

The system configuration of the whole cognitive support system is described as in Fig. 6. The assessment and training for cognitive is done by using user input and cards with RFID tags, in which is RFID tags can be read by RFID reader connected to the computer by using communication line and USB power source. The identification process is performed in the computer and the results are shown through the monitor of the computer.

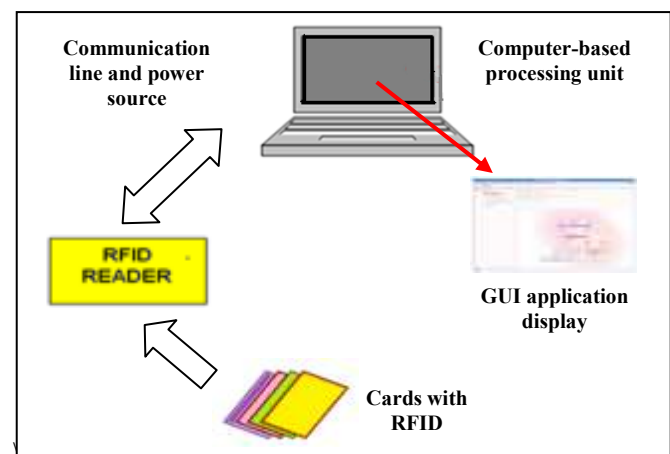


Fig. 4: Configuration system for the cognitive ability assessment and training support system.

3.4 Software Implementation

Visual C# programming is used to be an easy reference for interfacing with the user of the cognitive ability support system. Fig 5 shows part of visual C# programming language that has been developed for GUI application of cognitive assessment.

```

private void listBox1_SelectedIndexChanged(object sender, EventArgs e)
{
    int ItemsSelected = listBox1.SelectedIndex;
    this.tableChilddataTableAdapter1.Fill(elissadbDataSet.tableChilddata);
    foreach (DataRow thedata in elissadbDataSet.tableChilddata.Rows)
    {
        //if (Convert.ToBoolean(thedata[9]))
        if ((int)thedata[0] == ItemsSelected + 1)
        {
            idTextBox.Text = Convert.ToString(thedata[0]);
            childName.Text = (String)thedata[1];
            childBirthplace.Text = (String)thedata[2];
            childBirthdate.Value = Convert.ToDateTime(thedata[3]);
            String genderText = (String)thedata[4];
            if (genderText.Equals("Male"))
            {
                gendercomboBox1.SelectedIndex = 0;
            }
            else
            {
                gendercomboBox1.SelectedIndex = 1;
            }
            childNickname.Text = (String)thedata[5];
        }
    }
}

```

Fig. 5: Source code for GUI application

The algorithm of the cognitive ability support system can be seen through the flow chart in Fig. 6. There are three main parts in the cognitive ability support system. First part includes user data which consists of input storage and update data. Second part is the assessment generation and lastly report and training guidance generation.

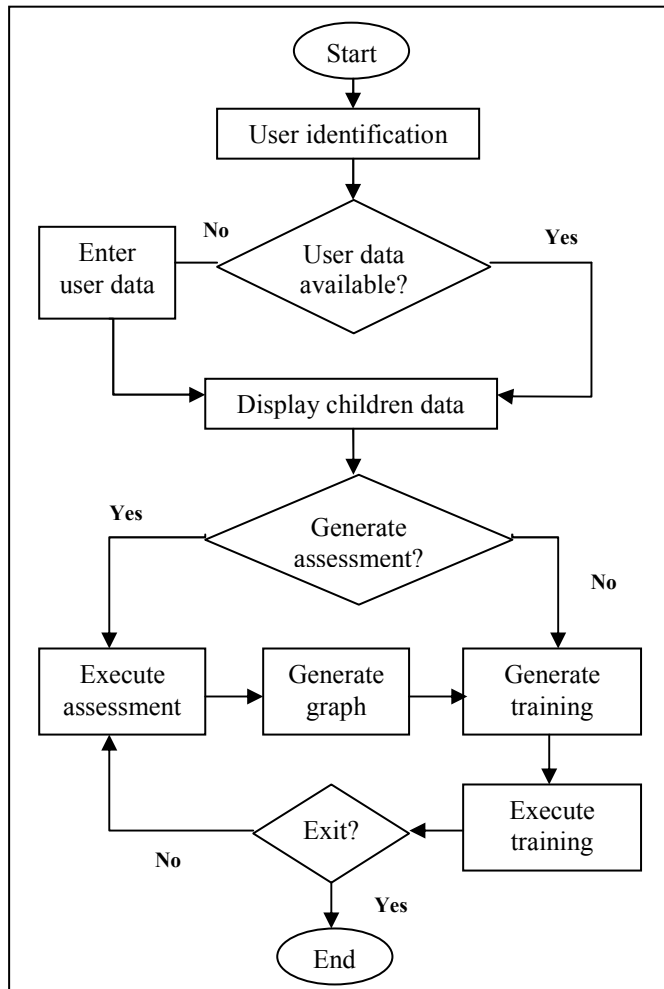


Fig. 6 Software algorithm

4. Design and Implementation

4.1. Implementation of Cognitive Ability Support System

This part is important in order to make sure that the support system can give an efficient impact for special children. The method of assessment and training for special children in cognitive ability is to locate the level of the children and give appropriate training to them. In order to train the children effectively, this support

system use images which special children can see or identify in real situation. The support system will assess and train the children in cognitive ability by using related cards with RFID tags and also other training tools.

4.1.1 Cognitive Ability Menu

The concept of the cognitive ability support system is generally to train children for their logical thinking and memory skills. Once they have learn this, they will be able to communicate and can memorized things happen around them in daily life. The cognitive ability menu divided into two parts, which is menu for assessment and menu for training.

The menu of assessment menu consists of 113 assessments that needed the trainer or parent the answer in order to know the level of the children accurately. While the menu for training consists of 39 trainings with description which can cover all the important skills that needed for cognitive ability such as perception, logical thinking and so on.

4.1.2 Assessment and Training Tool

Special children are normally preferred to colours, pictures, and toys. In order to make this support system more interactive, there are three types of tools used in this cognitive ability support system, some of them include RFID tags.

- 1) Toys for training (e.g. ball)
- 2) Pictures with RFID tag
- 3) Training (computer based)

4.2 The Assessment and Training Method

The method of assessment and training for special children in cognitive ability is to locate the level of the children and give appropriate training to them. In order to train the children effectively in cognitive ability, this support system uses images which special children can see or identify in real situation. The support system will assess and train the children in cognitive ability by using related cards with RFID tags and also other training tools.

This support system is designed in simple and attractive interface as shown in Fig 7. It has been designed with a necessary log in page in order to ensure that the children data is secure from access by others. The display of GUI application also has interactive sound display to interact with the children.

Log In

UserName:

Password:

label5

Fig. 7: GUI for cognitive ability support system

The trainers or parents are required to fill in the children data form before they proceed to the assessment part. The data of children will be saved in Microsoft Access so that the children data will be saved and manage automatically in computer.

Next, they will go to assessment part of the support system. The trainers or parents have to rate the children ability regarding to the name of assessment by clicking yes or no and also by using cards with RFID tags.

After trainers done the assessment, the result in graphical form will show as in Fig 8. The result shows the level of achievement of the children in each particular group. The graph shows the result of the children in each group



Fig. 8: Result in graphical form

The suggested training table will be shown after the trainers proceed to the next part. Suggested training table is design to help or as a guidance for the schedule of training for the children.

The suggested training table consists of date and time that suitable for the trainers to train the children. The trainers can determine which group of training should be given to the children from the graph and then choose the suitable training table.

Every time when a new child is registered in this support system, the database will detect the information entered by the user. Fig 9 shows the children data that has been stored in database. The database for children data is saved in Microsoft Access in table form. It is bounded to the program so that the software can retrieve data from Microsoft Access when it is required. The main advantage of using Microsoft Access for children data management is the ease to be retrieved and organized.

ID	Name	Age	Gender	Height	Weight	Eye Color	Hair Color	Handedness
1	Tan, Yt. Hui. ameng	1/11/2010	Female	160	45	Brown	Black	Right
2	Tan, Yt. Hui. ameng	2/10/2010	Male	150	40	Brown	Black	Left
3	Tan, Yt. Hui. ameng	3/10/2010	Female	140	35	Brown	Black	Left

Fig. 9: Children data that have been successfully saved in database

Note that in Fig 10, the database for cognitive assessment list and training guidance are saved in XML format document. Very similar to Microsoft Access, he XML file is also bounded to the program in order for the program to retrieve and display the list when necessary. The main advantage of using XML format is the capability and ease to update the assessment list and training guidance list. This feature is important to ensure updated database of training guidance and assessment is being done to maximize the impact of the cognitive ability training.

```

<?xml version="1.0" encoding="utf-8" standalone="yes">
<training>
  <code id="201">
    text="Listen to voice for 30 seconds" tag="child"
    text="child actively regards the face of the adult"
    text="Turns eyes and head to sound of hidden voice"
    text="child turns to mother's voice"
    text="Localizes sound with eyes" tag="child"
    text="child finds a small toy to the left"
    text="anticipates visually the trajectory of a slowly moving object"
    text="child comes"
    text="Plays 2-3 minutes with a single toy" tag="child"
    text="child is actively involved with a toy"
    text="Follows trajectory of fast moving object" tag="child"
    text="child follows and finds a rapidly"
    text="looks at pictures one minute when asked" tag="child"
    text="child enjoys looking at pictures"
  </code>
  <code id="202">
    text="Listens selectively to familiar words" tag="child"
    text="child shows signs of understanding"
  </code>
</training>

```

Fig. 10: Database for updating assessment and training data

Several user acceptability tests had been done on the display of the layout, font size of the contents, contents, use friendly application, transaction time to detect RFID card and also sound display. The feedback and comments were collected, analyzed and the support system is improved and revised. After that, it is shown to experts in both engineering and educational fields and the positive comments were obtained.

5. Testing and Optimization

5.1. Result in Graphical Form and Training Guidance

After trainers done the assessment, the result in graphical form will show as in Figure 11. The result shows the level of achievement of the children in each particular group. The graph shows the result of the children in each group.

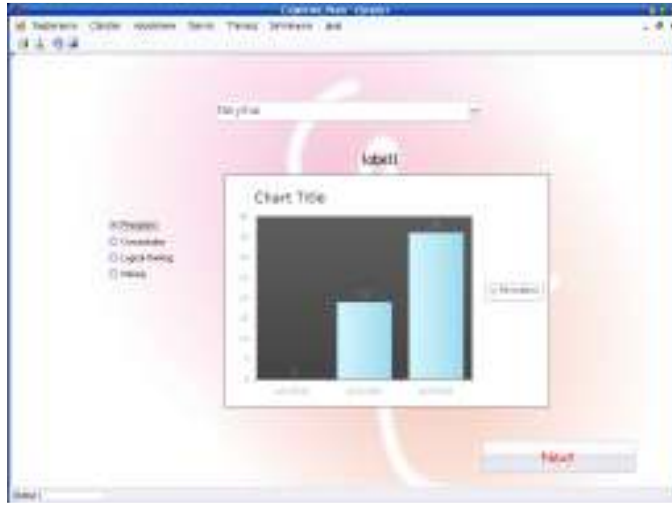


Fig. 11: Result in graphical form

The training table will be shown as in Fig. 12 after the trainers proceed to the next part by clicking the “Next” button. Training table is design to help or as a guidance for new trainers to train the children.

Fig. 12: Training Table

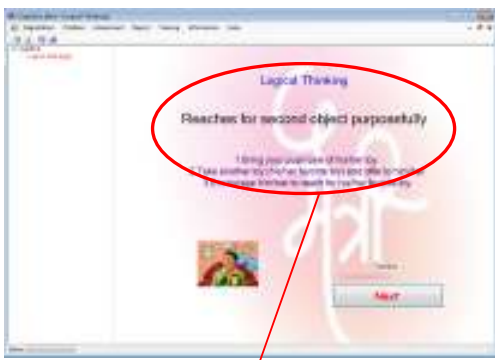
The training table consists of date and time that suitable for the trainers to train the children. The trainers can determine which group of training should be given to the children from the graph and then choose the suitable training table. After choosing the suitable training, the trainers can start the training by clicking on the tab provided or follow the sequence of the program. The training will start after the trainers clicking on the button “Training” in the suggested training table form.

5.3 User Acceptability Test

Table below shows the user acceptability tests that have been done on the display of the user friendliness of the application, language, transaction time to detect RFID card and also sound display.

Table 4
User acceptability test

Events	User Feedback
User friendliness	 Fig. 13: User Friendliness of the support system The tab menu in the support system makes the support system easier to be used and users can always proceed to any part of the support system that they wish to proceed to.

Language used are easily understood	 1. Bring your pupil one of his/her toy. 2. Take another toy (his/her favorite toy) and offer to his/her. 3. Encourage him/her to reach for his/her favorite toy. Fig 14 Language used in the support system The words and sentences used within the application are easily to be understood. It is helpful for trainers especially parents in order to use the support system effectively.
Transaction time to detect RFID card	The time for RFID detection is quite fast. Reading response is generally 0.01s.
Sound display	Sound display is satisfied. It has an interactive sound, effective for the implementation of the support system.

6. Conclusion

The cognitive assessment and training support system has been developed in order to help children with Down syndrome to improve the cognitive ability with the use of RFID technology. The support system also used for user data management in Early Intervention Program.

The cognitive ability is divided into four sub-groups which are perception, concentration, logical thinking,

and memory. The system is mostly focus on the software development for the support system. The graph for each sub-group in cognitive ability has been developed after the assessment to detect the level of achievement of the children and provide training guidance for parents or trainers.

The advantages of this system include the simplicity of the system and the utilization of conducive method to train children in cognitive ability. It is interactive and able to attract the attention of children.

For future works, it would be beneficial to develop a support system that consists of modules for other different developmental abilities, for example, for gross motor skill and fine motor skill. The system also should be designed to improve by using more RFID tags for more accurate result.

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