QURAN MEMORIZATION TOOL BASED ON THE ATTENTION OF HIGH-FUNCTIONING AUTISTIC USING EVOLVING LIVING TECHNOLOGY

NUR MADIHAH BINTI JAFAR

FACULTY OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2017

QURAN MEMORIZATION TOOL BASED ON THE ATTENTION OF HIGH-FUNCTIONING AUTISTIC USING EVOLVING LIVING TECHNOLOGY

NUR MADIHAH BINTI JAFAR

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF COMPUTER SCIENCE

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

UNIVERSITY OF MALAYA

KUALA LUMPUR

2017

ABSTRACT

In sustaining HFAs' attention during memorization the Quran verses is very challenging. Some of them suddenly switch to other activities, some of them still memorize the Quran verses but their eyes looking around or tapping the desk those give sorts of teachers' perception either the students still learn or their attention has been distracted. Nowadays, education is evolving due to the technology advances. The use of technological teaching aids becomes trends in a classroom. However, existing apps specifically developed for the HFAs concerning the memorization of Quran verses are hard to find. Thus, this research project is expected contributing something to the education sector by inventing a tool that will be effective in solving the problem. Literature review, interview, and observation were done to consider several aspects in developing the Quran Memorization Tool (QMT). There are; the adaptation of abilities of sensors and actuation which are introduced in the EVLIT, the adaptation of Neurofeedback Training (NFT) approaches (visual feedback, audio feedback, verbal response, and rewards), the components involved such as learning emotions, self-rewarding, (selective attention, sustain attention, memorization skill), adjust brainwave, brainwave data, receive brainwave, and memorization session. The analysis of the experimental result with the HFAs showed that the HFAs' attention performance was enhanced when they were rewarded with a video illustrates some abstract animation in the middle of distracted attention during the use of the QMT. It can be deduced that the invention of QMT is effective in enhancing the HFAs' attention during memorization of the Quran verses.

ABSTRAK

Usaha dalam mengekalkan fokus Autistik Berfungsi Tinggi (HFA) semasa menghafal ayat-ayat al-Quran adalah sangat mencabar. Sesetengah daripada mereka secara spontan beralih kepada aktiviti-aktiviti yang lain, dan ada juga yang kekal menghafal ayat-ayat al-Quran tetapi memandang sekeliling bilik darjah atau mengetuk-ngetuk meja hingga menimbulkan pelbagai persepsi guru sama ada pelajar masih memberi tumpuan ataupun tidak kepada pembelajaran mereka. Pada masa kini, pendidikan berkembang seiring dengan kemajuan teknologi. Penggunaan alat bantu mengajar berteknologi sudah menjadi trend di dalam bilik darjah. Walau bagaimanapun, aplikasi di pasaran semasa yang direka khas untuk HFA menghafal ayat-ayat al-Quran sukar ditemui. Oleh yang demikian, projek penyelidikan ini dijangka dapat menyumbang sesuatu dalam sektor pendidikan melalui penciptaan alat yang memberikan kesan positif dalam menyelesaikan masalah ini. Kajian literatur, temu bual, dan pemerhatian telah dilakukan untuk mempertimbangkan beberapa aspek dalam membangunkan QMT. Antaranya adalah: penyesuaian fungsi mengesan dan menggerak sebagaimana yang diperkenalkan di dalam EVLIT, penyesuaian pendekatan NFT (maklum balas visual, maklum balas audio, tindak balas lisan, dan ganjaran), komponen-komponen yang terlibat seperti emosi pembelajaran, memberi ganjaran, (fokus selektif, memanjangkan fokus, kemahiran mengingat), memperbaiki gelombang otak, data gelombang otak, penerimaan gelombang otak, dan sesi hafalan. Analisis ke atas hasil eksperimen terhadap HFA menunjukkan bahawa prestasi fokus HFA telah dapat dipertingkatkan melalui ganjaran video animasi abstrak apabila fokus terganggu ketika menggunakan QMT. Hal ini dapat disimpulkan bahawa rekaan QMT berkesan dalam meningkatkan daya fokus HFA semasa menghafal ayat-ayat al-Quran.

ACKNOWLEDGEMENT

First of all, thank you Allah the Most Gracious and the Most Merciful for giving me the opportunity, strength, and ability to pass all tests in the past four years to finish this research. I would like to thank all people who have helped and motivated me along the journey of my Master study. I mainly want to express my gratitude to my supervisor, Dr. Nazean Jomhari for her guidance, close supervision, and encouragement for me throughout this research.

I would also like to convey my sincerest appreciation to my beloved husband, Mohd Shafie bin Hashim who has been my backbone in all aspects of life, my family for their endless love and support during my life, my beloved late sister, whom had passed away a year ago for her support and commitment to me during my life, my two lovely sons for their endurance throughout the period of my study, and not forget to thank my friends Khaled Ismail, Nurul Nadhrah Kamaruzaman and Aqela Amer Nordin for their endless help, support and encouragements. I wish them all the best in future.

Finally, I would like to convey my gratitude to members of Akademi Fakih Intelek for their support and encouragements during the period of my research.

Nur Madihah binti Jafar 18/4/2017

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Overview of research

This research project is to investigate the impacts of Quran Memorization Tool (QMT) using Evolving Living Technology (EVLIT) in the attention performance of the High-functioning autistic (HFA). EVLIT comes with several approaches to be chosen in designing a certain system. However, in this research project, it will only focus on the approach; **integration of the abilities (sensors, actuation)** of naturally evolved life forms into bio-hybrid systems. The aspects that become the core direction for this study are High-functioning autistic, attention performance, memorization technique used in Quranic memorization, and EVLIT.

Due to retardation in mental growth and development suffered by these individuals with autism, may have caused slow development in their communication and social relationship, in which had eventually caused limited involvement in social activities (Chung et al., 2007). However, in other aspect, they are good in school-related skills. The rote memory of people with HFA is excellent in some areas (Crane, Pring, Jukes, & Goddard, 2012) and also possesses exceptionally high skills in several fields.

The HFA had reported facing attentional deficits which were caused by the inability to properly handle the attention field, where the visual spatial attention is located. Another reason of short attention duration especially for most lessons learnt is caused by unsuitable teaching tools choose; such as teaching aids. Teachers should be more creative and innovative (Maimun Aqsha, Melor, Noriah, Tajul Arifin, & Mohammed,

2009) in their teaching approach in school to attract the students' interest. This approach will make the knowledge transfer process easier to understand rather than dull by the students (Wan Noor Hazlina & Kamaruzaman, 2009a). Other than using conventional style in teaching the students, lots of technology gadgets can be used in capturing students' attention during lessons learnt (Roblyer, 2006; Siti Iradah & Rabiah, 2011).

Nowadays, there are robustness of apps and tools those are developed for typical individuals in memorizing the Quran. It provides with various techniques of memorization. However, some of the HFAs no longer interested to use it after a period of time. The cause of repeating in using the same tools or reading the same phrase will affect their attention. The techniques used in memorizing the verses of Quran are also not often suitable for the HFAs. This situation may impede their Quran memorization progress.

Most of the HFAs do not know how to read the text of Quran which are written in Arabic language. In memorizing the verses of Quran, they prefer listening to teacher's recitation or Quranic audio by using apps or tools. This situation may give challenges to teachers as they are difficult to notice that their students still focus on memorization or otherwise since they not always look at the texts of Quran while listening.

Due to these cases, the purpose of this research project is to introduce a new tool with a few new styles in memorizing the verses of Quran for the HFAs using the EVLIT. This QMT will be a technological teaching aid that supports the memorization of Quran verses for the HFAs that enhances their attention and assists teachers in ensuring students' participation in learning process. In addition, this research make an effort to contribute the needs of inventing a technological teaching aid in the Quran teachings for the HFAs as existing teaching aids which are suitable for the HFAs mostly developed

for non-Islamic education subjects. More so, the features adopted by the teaching aids tools are not totally suitable for the HFAs.

1.2 Problem Statements

At the early age, infants with autism have shown less attention compared to typical children (Patten & Watson, 2013). The difficulties in paying attention may impede their learning progress. This situation may cause a few groups of students with autism left behind in lessons learnt as they need a few special methods to be used by teachers in teaching them. In the context of memorizing the Quran verses, the HFA students fail to memorize the Quran verses in a longer term.

Although students with autism have excellent rote memory (Crane & Goddard, 2008), they are easily distracted with environment which things happening around them. It will become worst when set of tasks given are seen not interested to them. Various software learning application systems or technological teaching aids have been developed to assist people memorize the Quran verses. However, the existing apps are unsuitably developed for the HFA students. From the observation done in the memorization of Quran verses programme for the HFA students (preliminary study), most of the students were no longer interested to memorize the Quran verses after a period of time when using the same apps along the memorization session. Therefore, there should be technological teaching aid specifically developed to suit the use for the HFAs (Ploog, Scharf, Nelson, & Brooks, 2013).

In order to memorize the Quran verses, the HFA students were seen not appropriately apply existing memorization techniques such as tally method, listening to the Quran recitation by their own, and pointing one by one the Quran verses using digital pen; for

instance in using the tally method to memorize the verses of Quran, a few students eager to finish task given very quickly. Thus, he ticked two to three boxes for every recited verse.

Therefore, for gaining and increasing the attention of HFA students during memorization of the Quran verses, how do we develop a system so that it suits for the group of autistics usage?

1.3 Research Questions

What is the relation between EVLIT and neurofeedback training?

How neurofeedback training be used to increase the attention?

What are the effects of using neurofeedback training in the Quran Memorization Tool?

1.4 Research Motivations

Learning the Quran is one of the branches in Islamic Education. The Holy Quran is sent to human to be their guidance. The verse 25:1 in the Quran says “Blessed is He who sent down the Criterion upon His Servant that he may be to the worlds a warner.” According to the verse, the phrase “His Servant” also includes the minorities such individuals with high-functioning autism who are not of exception when it comes to getting exposure to the knowledge contained in the Quran (Wan Noor Hazlina & Kamaruzaman, 2009a). Being exposed to the Quran, especially to the HFAs is important in shaping their social skill and further in instilling Muslim characteristics in themselves.

These students have the capability to remember things quickly, to have reduced hyperactive problem from time to time, to listen to instructions and simple communication language, and to manage themselves (Siti Iradah & Rabiah, 2011). These observations have encouraged this study to find the best way to prolong the term in memorization the verses of Quran among the HFA students.

Since neurofeedback training is successfully training the attention performance, and it shown good research support for its effectiveness in treating autism (Hammond, 2008), this research which is about to enhance the HFAs' attention performance during Quran memorization will use the neurofeedback training as a method in implementing the EVLIT.

1.5 Research Objectives

Three objectives to be achieved in this research are as follows:

1. To identify HFAs' attention performance, favourite activities done when the HFAs losing focus and the most suitable technique in the Quran memorization for HFAs.
2. To design a new tool that enhances the Quran memorization attention among the HFAs using neurofeedback training.
3. To measure the effectiveness of the Quran Memorization Tool on the attention performance of HFAs using the Evolving Living Technology (EVLIT).

1.6 Significance of Research

The significance of this research is to contribute something valuable to the Muslim autistic community as they are also have the rights to learn, understand, and instill all teachings of the Quran in their heart. In order to ensure the autistics are able to memorize the verses of Quran for a longer term as typical individuals, a unique method should be introduced to them. Following today's technology advances, a technological teaching aid integrated with the EVLIT, named the Quran Memorization Tool will be introduced and adapted to the HFAs.

1.7 Scope of Research

This study concentrates on developing a new application or tool which will serve as a better technological teaching aid for the HFA students, specifically to support their attention in memorizing the verses of Quran. In this research, *sura al-Jumu'ah* of the Quran (62nd sura of the Quran) would be tested for the system evaluation. The sura was chosen randomly to be tested as the students not memorize it yet. The new tool named Quran Memorization tool then will be distributed in the HFA Muslims community with the aim to gain and longer the term in memorizing the verses of Quran based on their current attention level using the NeuroSky MindWave headset (Mindset) as a measurement tool in detecting the level of attention.

This new development tool would be based on the level of attention of the HFA students. In order to longer the attention span, their current level of attention was first detected by the Mindset. The threshold value for the attention score is 40. As their current level of attention value was 40 or below, the motivational incentives (the HFAs' interested activity) would be provided by the tool. When performing the interested

activity while their attention value detected was above 40, the tool would stop the activity and continue to the memorization of Quran verses part. Before adopting a motivational incentive (the HFAs' interested activity) to be put into the tool to increase the students' attention span, few observations and interviews were done to identify the HFAs' favourite activities when HFAs losing focus while memorizing the verses of Quran. The observations and interviews resulted that watching videos is the most interesting activity to the students. The previous researches were also proved that the type of video that fascinates people with autism is video with abstract animation. So that, in this development tool, the *sura al-Jumu'ah* video with abstract animation was provided for the students to get some refreshing.

The development of this QMT would consider a suitable Quran memorization technique for the HFAs. The tool would combine different techniques applied by the typical students while memorizing the Quran verses. This is because the HFAs have their own unique style in memorization. This was proven by previous research. Thus, they are need for audio, visual, verbal response, repetition, and rewards techniques in memorizing the Quran verses.

Autism categories are too broad. This research would only focus the students with high-functioning autism. As mention in the earlier section, the HFAs have the capability to remember things quickly, to have reduced hyperactive problem from time to time, to listen to instructions and simple communication language (Siti Iradah & Rabiah, 2011). Since the criteria are shown by the students, it is a pleasure to boost their strengths in memorizing the Quran verses. In order to assess that the verses of Quran were memorized successfully by the students, they were evaluated either they were able or not to repeat the recited suras without looking to the sacred text or playing the Quranic audio. A few students face difficulty in literacy that causes them unable to recite

properly. However, by pronouncing few syllables either at the beginning or end of verses, they were considered memorize successfully.

Finally, in developing this new tool, the EVLIT was used in this system. In previous section, the approach chosen in implementing the EVLIT had been mentioned. In this research study, the approach chosen was: integration of the abilities (sensors, actuation) of naturally evolved life forms into bio-hybrid systems. This new tool would show the features of sensing and actuating when the student's brainwave signals were received by the brainwave reading headset. These brainwave signals were measured and stimulate the audio, visual or combined audio-visual feedback on the computer screen. Then, the student would respond to the feedbacks which results in brain adjustments when information about how to respond were available on that audio, visual or combined audio-visual feedback. The integration of both abilities (sensing and actuating) to form a bio-hybrid system was featured in a neurofeedback training system.

1.8 Expected Outcome

The expected outcomes of this research are as follows:

Attention improvement in the students with high-functioning autism: This study provides opportunity for the students with high-functioning autism to enhance the attention performance during memorization the Quran verses by increasing their attention span.

Provides knowledge for other researchers: There are lots of study that focus on enhancing attention using games throughout neurofeedback training but none of the studies are about to improve the attention using neurofeedback training for the HFAs in memorizing the Quran verses. Furthermore, the EVLIT is quite new in technology advances today. Hoping that, with this study, it provides new knowledge about inventing the Quran learning tool systems using the EVLIT.

The right and suitable memorization technique for the students with high-functioning autism: This study suggests the best technique to be applied in memorizing the Quran verses among the students with high-functioning autism.

The understanding of students' learning pattern: This study assists teachers to understand more about their students' behaviour by knowing the most favored activities done when the HFAs lost focus while memorizing the verses of Quran. Once they know the students' weaknesses or strengths then easier for teachers to attract their attention during learning session.

1.9 Organization of Report

This thesis is organized into six chapters which are described as below:

Chapter 1 gives overview of the research study with the problem statements retrieved from observation and literature which encourage to the needs of this study then led to the objectives to be looked into. The research questions, motivations, significance, scope, and expected outcome from this study were also presented here.

Chapter 2 discusses the previous studies that support this research; also it gives understandings about the HFAs and their behaviour while learning, their learning style, and their abilities to memorize. Besides that, existing interventions of the Quran education, constraints in teaching the Quran to the HFAs, existing Quran memorization techniques, and existing memorization tools for the HFAs were also explained. Other discussions included were about living technology versus EVLIT, existing systems those used the EVLIT features, the neurofeedback training practices among the HFAs, brainwave reading headset as well as the reviews of existing frameworks for developing learning system using neurofeedback.

Chapter 3 explains the research methodology and preliminary study in identifying the HFAs' attention performance when memorizing the Quran verses, the favourite activities done when the HFAs lost focus while memorizing the Quran verses, and the most suitable Quran memorization techniques used for the HFA. The outcome of the preliminary study would answer the objective 1 of this study.

Chapter 4 describes the design and development of the QMT based on the proposed system framework. The components of the system were discussed here. Besides that, the analysis of the QMT and the graphical user interface were also provided.

Chapter 5 presents the analysis of experimental result of the QMT. The objectives of the validation and hypotheses to be tested were described here followed by the explanation about the experiment methods and procedures. Finally, the result and analysis of the validation were presented.

Chapter 6 provides the summary and conclusion of this research study. The achievement of each objective was discussed. Discussions of the research findings, answers of the research questions, the research limitation, as well as the suggestion for future enhancement were also elaborated.

CHAPTER 2

LITERATURE REVIEW

2.1 Background to Autism

Autism Spectrum Disorders (ASD) is understood as mental dysfunctions happen in an individual with autism and it is associated with the cognitive impairments (Bölte, Holtmann, Poustka, Scheurich, & Schmidt, 2007). This group of individuals have cognitive deficits including perception, memory, and language abilities (Prior, Gajzago, & Knox, 1976; Rajendran & Mitchell, 2007). These difficulties may affect people with autism having problems in communication skill, social relationships, and behaviour (Bouvet et al., 2014; Barendse et al., 2013; Silverman, Yang, Lord, & Crawley, 2010). Three types of ASD have been listed as identified by American Psychiatric Association using diagnostic manual (DSM-IV) which had been reviewed and revised until DSM-V was released. The main sets of disorders are Asperger's syndrome, Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS), and Autistic disorder (Mandy, Charman, Gilmour, & Skuse, 2011). Previous research studies prove that ASD could be affected individuals from multi-racial background. Majority of them are male with ratio 3:4 (Lamb et al., 2005). The Figure 2.1 below is the prevalence rates for ASD with *n* in 10,000 of all children in the general population (Gillberg, Cederlund, Lamberg, & Zeijlon, 2006).

Age cohort (Birth year)		Boys	Girls	Total
1989–1994	ASD cases	205	57	262
	Total population	16644	15924	32568
	ASD prevalence	**123.2**	**35.8**	**80.4**
	Autistic disorder	54.1	15.7	35.3
	Asperger syndrome	10.8	2.5	6.8
	Disintegrative disorder	0.6	0	0.3
	PDD NOS	57.6	17.5	38.1
1983–1988	ASD cases	141	34	175
	Total population	14822	13685	28507
	ASD prevalence	**95.1**	**24.8**	**61.4**
	Autistic disorder	25.0	10.2	17.9
	Asperger syndrome	27.0	2.2	15.1
	Disintegrative disorder	0	0	0
	PDD NOS	43.2	12.4	28.4
1977–1982	ASD cases	82	27	109
	Total population	20052	21358	41410
	ASD prevalence	**40.9**	**12.6**	**26.3**
	Autistic disorder	14.0	7.0	10.4
	Asperger syndrome	14.0	0.5	7.0
	Disintegrative disorder	0	0.5	0.2
	PDD NOS	13.0	4.6	8.7
1977–1994	ASD cases	428	118	546
	Total population	51518	50967	102485
	ASD prevalence	**83.1**	**23.2**	**53.3**
	Autistic disorder	30.1	10.6	20.5
	Asperger syndrome	16.7	1.6	9.2
	Disintegrative disorder	0.2	0.2	0.2
	PDD NOS	36.1	10.8	23.5

Figure 2.1: Prevalence Rates for ASD

The issue of autism cases is on the rise become one of the hottest topic reported in clinicians, specialists, or researchers studies (Schreibman & Stahmer, 2006). (Dave & Fernandez, 2015) reported that the increment in autism prevalence is from 0.5 to 14.7 per 1,000 children over 1970-2010. Thus, many speculations about the causes of autism due to this increment cases including problematic cortical synapse (Garber, 2007) and genetic factors that affect neurological system (Chubykin et al., 2005; Jamain et al., 2003). However, the facts are still unclear (Courchesne et al., 2007).

As mentioned earlier, the cognitive deficits in individuals with autism may disrupt learning abilities. When they have difficulties in verbal communication, they are struggling to understand the communication as well as delayed in speech learning (Barrett, Prior, & Manjiviona, 2004). Due to those deficits, they would feel hard to understand others social behaviour (Farmer, 2000; Fujiki, Brinton, Morgan, & Hart, 1999) and also would hinder them to perform well in group learning. Learning in

imaginative play may trouble people with autism (Barrett et al., 2004) and solitary play is more preferred by them (Mikami & Hinshaw, 2003). By understanding this minority group of learning pattern, many interventions and structured programs has been developed so their rights to learn as typical individuals are preserved.

The severity of behaviour problems in people with autism could be ranged from very severe to mild (Bourgeron, 2009). Severe behaviour problems are more aggressive rather than milder form (Billstedt, Gillberg, & Gillberg, 2005; Rajendran & Mitchell, 2007). People in the milder form usually have mild psychiatric problems (Billstedt et al., 2005) and only major suffering in social relationships and communication. However, most of kids with autism easily to get tantrum when they are upset, anxious, or angry (Bernad-Ripoll, 2007; Potegal, Carlson, Margulies, Gutkovitch, & Wall, 2009). When tantrums behaviour happens in autistics, they may show unpredictable reaction. Some of them go into state of fear and panic then causing crying, screaming (Kanner, 1943), pushing or throwing anything away, and more aggressive behaviour would happen such as biting or hitting others (Maskey, Warnell, Parr, Le Couteur, & McConachie, 2013). However, they are also may experience unusual passivity (Bonde, 2000; Stevens, Fein, & Waterhouse, 2000). Helping them to handle frustration, how to express anger in a right way, and control the passive behaviour is very crucial to deal with their emotions. These challenges may push parents to choose the best solution so autistic children are able to control emotions themselves.

Individual with autism have their own special interests. One of the core domains of autism is repetitive interests (Barendse et al., 2013; Barrett et al., 2004; Zandt, Prior, & Kyrios, 2007b). In doing activities those they obsessed with, they are tending to repeat several times for instance, drawing the same objects again and again, listen to the same music and playing the same part in video CD (Bouvet et al., 2014; L. B. Silverman,

Bennetto, Campana, & Tanenhaus, 2010). In employment sectors, these people with autism prefer a structured and high degree of repetition jobs. For instance, the jobs that involve manufacturing, warehousing, printing, and recycling (Smith & others, 1995).

In Malaysia, there are variety of services provided to help people with autism improves the cognitive and learning skills such as education in a mainstream setting through Integration of Special Education Program (PPKI), early intervention and vocational training as practiced in National Autism Society of Malaysia (NASOM), and learning Quran with the guidance of trained teachers under the Yayasan Faqeh consultation.

2.1.1 High-functioning Autism and Behavioral Pattern

High-functioning autism spectrum disorder is a common term used among researchers. It is also an informal term applied to individuals with pervasive developmental disorders not otherwise specified (PDDNOS) without intellectual delay as well as children with Asperger's syndrome (Association & others, 2013).

According to Michelle Turner (1999), the behavioral pattern of the high-functioning autistic (HFA) as well as their interests and activities those they obsessed with can be classified into two distinct groups: Lower level and Higher level behaviors (Sansosti & Powell-Smith, 2010) as shown in the Figure 2.2 below.

Figure 2.2: HFAs' Behavioural Pattern

2.1.1.1 Lower Level Behaviour

The HFAs in this category may exhibit stereotypic movement disorder (SMD). The childhood often would do the repetitive involuntary actions such as hand flapping and head banging. The repetitive motor movements are usually known as self-stimulatory or self-stimming. The self-stimulatory behaviour (repetitive motor movements or repetitive movement of objects) can be observed in any one or all senses (Edelson, n.d.). Examples of the self-stimulatory behaviour that related to various senses are as follows:

1) **Visual senses**: Staring at repetitive blinking, moving object in front of the eyes, hand flapping
2) **Auditory senses**: Clapping, making vocal sounds, tapping ears
3) **Tactile senses**: Scratching, touching the skin with one's hands
4) **Vestibular senses**: Afraid of heights, rocking front to back
5) **Taste senses**: Licking body parts or objects, put objects or body parts into one's mouth
6) **Smell senses**: Sniffing people, smelling objects

They would show these kinds of behaviors when sensing happiness, frustration, or agitation. The failure to predict outcomes and failure to process sensory may contribute to self-stimulatory behaviour.

2.1.1.2 Higher Level Behavior

The HFAs in this category doing the more complex repetitive behaviors (Mash & Barkley, 2003) includes elaborate routines and circumscribed interests. Individuals at younger ages includes adolescents often display these complex series of motor movements such as rearranging toys by order of colour, continuously watch the same video, and food preferences (same sequence of events of daily activities). The more complex circumscribed interests those are observed among the HFAs usually involve memorization of quotes or facts related to a specific topic (Mash & Barkley, 2003) such as the features displayed on every reverse side of each Malaysia banknote and dialogs uttered by animated characters in a cartoon movie.

The obsessive of repeating the same activities or interest may give benefits especially to the HFAs themselves if their obsession is seen as strengths. Based on their own strengths, the educators, parents or care givers are responsible to find the best and creative intervention strategies for the HFAs' development in many aspects.

2.1.2 High-functioning Autism and Learning Style

It is important to know one's learning style as it affect an individual performance in an educational setting. Generally, people tend to learn visually, auditorily, and/ or kinesthetically. For a typical people, they use more than one learning style (M. Edelson, 2016). The autistics differ from the typical as they depend on only one learning style.

The tendency to use a particular learning style can be identified by observing the person during learning time. If the autistics eager to look at pictures in the books, enjoy watching the videos even without sound, and love to look at what other people or objects do, thus they could be identified as visual learner (M. Edelson, 2016). If they prefer to imitate the phonetic sounds made by adults, repeating saying the adults' words, enjoy listening to recorded voices or music, and feeling excited when people talking to him/her, therefore they could be classified as auditory learner (MyAspergersChild.com, 2011). When the autistics repeat pushing the buttons (imitating the adults), taking things apart and match it again, then they could be kinesthetic learner (M. Edelson, 2016).

Although the HFAs more dependent on only one learning style, commonly they require for the combination of the three learning styles (Moreno & O'Neal, 2000). When giving a task to be completed, the teacher must break the steps into several smaller steps so it would be easier for them to understand. The steps included maybe visually, verbally, or physically. In order to aid them visually, visual cues like pictures and written words are needed. In terms of verbally, it is necessary for teachers to give a concrete and detail explanations or instructions as HFA have difficulties in understanding vague words. In assisting the HFAs to understand or know something physically, the best way are to let them touch and taste it themselves (M. Edelson, 2016).

It is necessary to do HFA group in order to design an educational or therapeutic program as different HFA students possess different learning styles (Tsatsanis, 2004). This is to ensure the benefit of the programs will be delivered among them. It is likewise the design of a teachnological teaching aid or tool needs for personalization.

2.1.3 High-functioning Autism and Memorization

According to the research done by Junichi Takahashi and his colleagues (Takahashi, Gyoba, & Yamawaki, 2013), they had proved that individuals with high-functioning autism have no issues with the visual short-term memory as reported in individuals with low-functioning autism regarding the spatial complexity of configurations. The greater complex the configuration is, the lower the visual short-term memory capacity is. However, individuals with HFA have no difficulties to memorize complex configuration as well as the simple configurations as they manage to organize the local features into global information when the pattern of configuration become complex.

2.2 Attentional Theories and Strategies

Attentional impairment is a core deficit suffered by autistics when it comes to making complex decision and psychomotor activities (Goldstein, Johnson, & Minshew, 2001). The deficiency at the level of executive control (cognitive control) causes disturbance in attentional system as executive control acts in performing tasks those involve initiation, selection, and execution (Rubinstein, Meyer, & Evans, 2001). Incapability to interpret significant stimuli is also one of the reasons of attentional deficits (Bryson, Wainwright-Sharp, & Smith, 1990; Jacob A Burack, 1994). Tasks those involve voluntary actions or volitional tasks such as complex decision making are difficult to autistics rather than reflexive orienting actions (Minshew, Luna, & Sweeney, 1999). It is also identified that no deficits in autistics when tasks given involve visual orienting but the autistics showed the disabilities in disengaging or shifting attention and auditory continuous performance tasks (Casey, Gordon, Mannheim, & Rumsey, 1993) as increment in attentional processes take place (Wainwright & Bryson, 1996; Wainwright-Sharp &

Bryson, 1993). However, individuals with autism are able to sustain attention when they have the self-determination (J A Burack, Enns, Stauder, Mottron, & Randolph, 1997).

2.2.1 High-functioning Autism and Attention in Learning

Most individuals with HFA face difficulties to pay attention during the learning process. This is also explained by (Murray, Lesser, & Lawson, 2005) in her article that people with autism have feature of atypical patterns of attention. At the early age, children with autism also have shown unusual characteristics of attention compared to typical children (Patten & Watson, 2013). Individuals with ASD impaired in the sustained and focus-execute attention. This was expected by (Nydén, Gillberg, Hjelmquist, & Heiman, 1999) by referring to the terms of (A. F. Mirsky, 1987; Allan F. Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). The sustained attention refers to the duration of responses by children when giving a task stimulus while the focus-execute attention means selecting or focusing to a critical stimulus. People with autism can be classified as monotropic individuals because they find it difficult to pay attention to so many things, simultaneously (Murray et al., 2005).

The cognitive deficiency such as explained above for most individuals with Autism Spectrum Disorder (ASD) is related to lifelong disability (Billstedt et al. 2005) but it has not been proved to prolong in adults with HFA (Cederlund et al. 2010). Despite this fact, there are indications that suggest lifelong disability is more dominant at this age. Due to this situation, an intensive training program can give extensive positive effects and benefits to these individuals (Kyong-Mee et al. 2007).

Attentional system in individuals with autism is about how the selective attention encourages them to give more attention to a familiar stimulus even though few stimuli

are presented simultaneously. This would be happened as their working memory stores previous information (familiar stimulus). This situation affects their ability to sustain attention for a longer term (Thomas, Vinod, & Guan, 2013). Few researches have proved that when learning tool inventions were embedded with familiar stimuli, the autistics' attention performance was improved (Bilikis, Nazean, & Rodina, 2015).

2.3 Importance of Quran Education for HFA

(Zawawi Hj. Ahmad, 1996) said a comprehensive teaching of Islamic Education subject is important to students. He also emphasized the practical aspect and experience in daily life. These statements are in line with the philosophy of Islamic Education as follows:

> *Islamic Education is a continuous effort to deliver knowledge, skill and emotional experience based on al-Quran and as-Sunnah…* (Ab. Halim, 2007)

The holy Quran is a main guidance for Muslim's life. It is one of a sound therapy and this has been proven in the research done by (Dini Farhana & Melati, 2011). They revealed that by listening to the verses of Quran, working Muslim women were found to have more serenity and manageable stress. (Shafiei, Salari, Sharifi, & others, 2011) and (Majidi, 2004) found in their research that patients who have physical and mental stresses when admitted to operation room will find it calming and they showed reduction of anxiety after listening to the Quran recitation. This clearly shows that listening to the Quran recitation as well as memorizing the verses can be a therapy to the emotion, which is thus suitable to be practiced by HFAs who occasionally show some behavioural problems.

2.3.1 Constraints in Teaching and Learning Quran in HFA

The Quran exposure among children with autism by listening to the Quran recitation and learning to recite the Quran is very crucial to ensure they stay calm and let them familiar with verses of the Quran (Siti Patonah, Zulkifli, & Durriyyah Sharifah, 2013). However, there are few constraints in giving the Quran education for them.

The hard situation when it comes to learn the Quran, the HFAs facing difficulties to sustain attention during learning. The use of traditional style of learning the Quran which requires the teachers to read verses of the Quran directly from the sacred text in front of the students may affects the HFAs' attention (Bilikis et al., 2015). As different HFA students may use different learning style (Tsatsanis, 2004) as mentioned in the earlier section, it should be the best way to provide them with multiple approaches of teaching, thus they would have the benefits from the learning moments.

Moreover, there are very few societies and education agencies which put the high priorities in providing the Quran therapy and learning for students with autism (Haq, 2014; Siti Patonah, M. Y. Zulkifli, & Durriyyah Sharifah, 2014). As Quran is one of the behavioural therapy (Siti Patonah et al., 2013), it is supposedly good for these students to have the Quran knowledge first before learning other skills and subjects. Maybe this idea should be put forward for consideration by the authorities and we should assess the result.

2.3.2 Intervention of Quran Education for HFA

The number of interventions of the Quran education particularly for HFAs is very little especially when many societies do not put Quran education as the high priorities. There are few examples of intervention those can be described as below. Each of them was presented in different methods.

According to the research conducted by Banire Bilikis and her colleagues (Bilikis et al., 2015), looking the strength of these students who are good in visual processing and rote memory, they tried to put an efforts to deal with the students' weaknesses (audio processing and attention during learning) by proposing a framework of Visual Hybrid for Learning Quran (VHLQ). The learning system of VHLQ may assist the students to improve their attention upon verses of the Quran recitation and text.

The other intervention is about school settings. *Sekolah Khusus Taruna al-Qur'an* which is located in Yogyakarta, Indonesia provides an Islamic special education for students with special needs especially the autistics (Desti Widiani, 2015). The school offers various learning modules such as behavioural therapy, life skill, occupational therapy, including the Quran therapy. The Quran therapy is divided into several sessions (Haq, 2014). On weekdays, the Quran therapy is conducted after performing Duha prayer in congregation and before going back (after praying in congregation for Zuhr). During weekend on Saturday, there is only one session for the Quran therapy. The students are taught to recite dua, dhikr, and selected verses from the Quran. Commonly, the Quran therapy is named as *ruqyah* session and teachers are needed to recite together with the students. The other activities included during the school period are learning Quran and memorization the verses of Quran. Learning the Quran with the guidance of

teachers is very important as for the moments the students need them they are able to recite it without existence of their teachers.

Besides that, there was also a research group discussed about the techniques and methods used to teach the Quran for the HFAs. According to their article (Siti Patonah et al., 2014), in order to teach this community, the main aspects to be concerned when preparing lesson modules are i) Following their competency; ii) Rewarding system; iii) Contemporary learning tools and aids; and iv) Repetition. The importance of considering their abilities to learn something should be put as high priority to ensure they gain the learning contents. Positive reinforcement as tokens or praises should be given to the students to increase their determination in learning. Moreover, in a classroom setting, the teachers should not neglect to use learning tools especially the use of technology as learning aids to enhance students' cognitive skills. Most of the HFAs have difficulties in sense of hearing and attention, thus it is very important to do repetition when learning. All the techniques given should be practiced as teachers play a big role in determining their students' achievements.

2.4 Memorization Techniques and Strategies

In Islamic education, a meaningful learning process is when the learners manage to memorize the lesson learnt (Boyle, 2006). Memorization is one of an Islamic pedagogy method to assist an individual to embody knowledge in the Quran (A'ishah & Hardaker, 2013). One of the techniques used in memorization is repetition. As repeating read or recite something consciously, it will come out from mouth according to one's senses or perception. The early childhood education also emphasizes on memorization before practicing to write. However there are specific memorization strategies for different

learning styles. Every learner may have their own memorization strategies according to their own learning styles (Ng, 2014).

2.4.1 Visual Memorization

Some autistics face difficulties when teachers or caregivers change the way of teachings or procedures of tasks completion. Since the visual learners are easily to remember what they learn when seeing the pictures or visual images, the use of visual tools may assist the autistics learn and memorize systematically. Repeating use the visual tools causes the autistics remember the procedures or routines naturally (Quill, 1995).

Technology devices could be developed as teaching aids for students (Lin, Lin, Jen, Wang, & Chang, 2011) as it is classified as interactive learning with the existence of text, graphics, photos, videos, illustrations, sound, animation and 3D imagery (Graham, 1998). Therefore, the autistics may have potential to excel when visual interventions are being exposed to them especially with the use of video as tool for learning (Shipley-Benamou, Lutzker, & Taubman, 2002).

In order to ensure the memorization of what had read easier, the visual learners should find a peace and quiet place for memorizing (Ng, 2014). Other than that, the texts written on books should be put in colour code, rewrite over and over, draw diagrams or images relating to the facts, and walking around while memorizing.

2.4.2 Auditory Memorization

Islamic pedagogy privileges the orality. When it comes to memorization, the students must to quote the lesson learnt verbally (A'ishah & Hardaker, 2013). This situation is

benefit for auditory learners who are good in speaking and easy to remember lectures or conversations. The auditory learners memorize best when they try to create a story about what things to memorize and repeat aloud the verses or phrases until they are able to say it without looking at papers (Ng, 2014). Besides that, the auditory learners may record themselves talking then listen it back especially when sleeping to help them remember better. Other than that, it is also good for auditory learners to listen to others about the things or facts they need to remember.

2.4.3 Kinesthetic Memorization

The tactile learners feel comfortable and easy to learn something by doing and touching it as they prefer a real situation. They love hands-on work such as constructions, cooking, drawing, and other works those involve moving around. In order to remember the things they had learnt, they require for an open area as it necessary for them to walk around and dislike staying for a long period. They are also need to use creative techniques involving all the senses they have. Memorizing whole things is not a good idea, instead of that it is necessary to split it up by writing on flashcards each of the words or phrases.

2.4.4 Existing Quran Memorization Techniques

Memorizing the Quran verses is a part of the Quran education. It is very crucial as the sacred texts from Allah SWT should be preserved (Azmil, Ab. Halim, & Misnan, 2013) for guidance to the future generation. There are lots of researches conducted were about the techniques used in the Quran memorization (Hifz). It includes the techniques used at the tahfiz institutes in Malaysia and other countries those practicing the Islam religion.

In this sub-topic, the popular memorization techniques used in Malaysia and other countries will be reviewed. In Malaysia, the memorization techniques those are quite familiar among the community are the *Jibril technique* and *Al-Huffaz technique.* The *Jibril technique* founder is Ustaz Mohammad Asraff Ayob Al-Hafiz. He experienced in memorizing the Quran about 15 years and teaching the Muslims community memorizing the Quran verses in seminars and workshops (Mohammad Asraff, 2011).

Ustaz Asraff proposed 10 suras to be memorized for the beginners to practice the *Jibril technique*. The 10 suras chosen are sura *yaa seen*, *as-sajdah*, *al-insan*, *al-mulk*, *ar-raHmaan*, *al-muzammil*, *al-jumu`ah*, *al-qiyaamah*, *al-waaqi`ah*, and *ad-dukhaan* (Mohammad Asraff, 2015). The *Jibril technique* is relevant to be practiced among the communities of workers, university students, house wives, and others who have many commitments to fulfill (Furqanworks, 2014). A hectic life is not a hindrance from memorizing the verses of Quran. This is strengthened with the verse 17 from sura *al-qamar*:

And We have certainly made the Quran easy for remembrance, so is there any who will remember?

The *Al-Huffaz technique* founder is Dr. Hj. Mohd Shafie Hj. Md Amin. He had served as a chartered accountant in a few firms including a Government Linked Company (A. Halimah, 2008). He expanded his knowledge by exploring about the Quran memorization and doing research on the Quran in local and overseas. He managed to memorize the 30 chapters of the Quran at the age of 30 years. With the encouragement to expand the knowledge of the Quran, he established a tahfiz school in Kuala Lumpur using the *Al-Huffaz technique* he developed his own.

The *Al-Huffaz technique* is focusing on the memorization of *'Amma* chapter (Mohd Shafie, 2005). The use of tally method (refer to figure 2.3) in this memorization technique assists the children to memorize the sura *al-faatiHah*, *an-naba'* until sura *an-naas* easily.

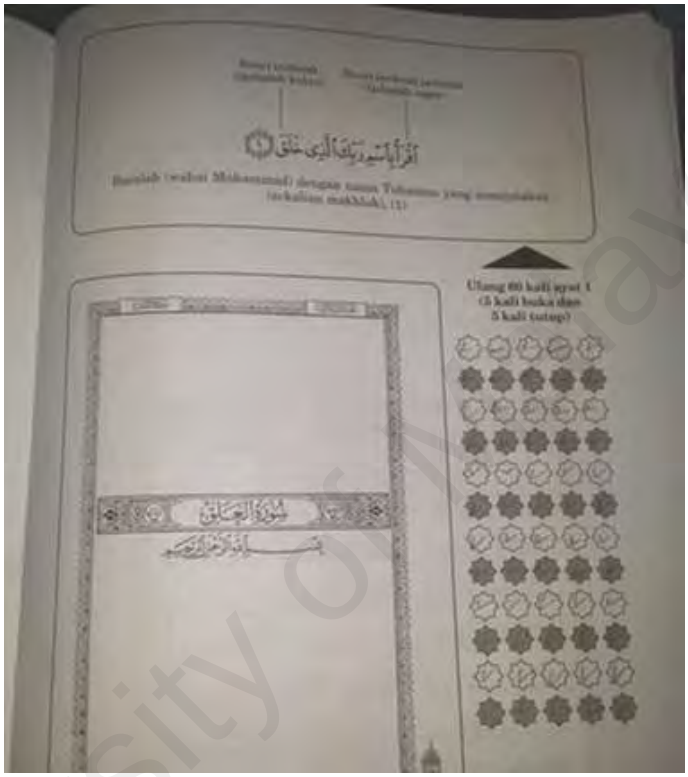


Figure 2.3: Marking the repeated recitation

The effectiveness of the technique had been being evaluated in a long duration. The result demonstrated that the children had been assisted with the *Al-Huffaz technique* i) were not easily forget the Quran verses those had been being memorized; ii) knew to manage the memorization schedule; iii) and able to recite the Quran well. Even though the *Al-Huffaz technique* is mostly used to train the children to memorize the verses of Quran, it is also recommended to be used by adults whom are willing to memorize the Quran.

The *sabaq technique* is also familiar in Malaysia especially in the tahfiz institutes. The term *sabaq* is to refer to the memorization of new verses of Quran (Zuldiah, 2012). The *sabaq technique* is usually practiced after Fajr prayer. The tahfiz students memorize a new verse in front of their teachers. If they fail to memorize the new verse, the teachers will give opportunity to memorize it again. There is tahfiz institute where the teachers give punishments if the students again fail for the second time (Abdul Hafiz et al., 2005). Some of tahfiz institutes divide the one day memorization activity into several sessions. These include *sabaq*, *5 sabaq*, *para sabaq*, and *sabaq nazirah*. (Sedek, Mustaffa, & Khadher, 2015). The term *sabaq* is also used in *khatam sabaq* which is referred to the successfully finishing the first time memorization of 30 chapters of the Quran (Azizah, 2012).

Besides the use of the above memorization techniques among the communities in Malaysia, the other memorization techniques those had been developed by the other countries are also practiced in Malaysia such as the *Deobandy technique*, *Amokhtah technique*, and *Turkish system technique*.

The *Deobandy technique* is from Pakistan and it is practiced in some of tahfiz institutes in Malaysia such as Madrasah Tahfiz al-Quran Miftahul Ulum in Sri Petaling (Sedek et al., 2015) and Madrasatul Quran, Kubang Bujok (MQKB), Serada, Kuala Terengganu (Azizah, 2012). The importance of practicing this technique as choosing chapters from the back of the Quran allows the students to memorize the short suras which are short and simple verses as well as often read during prayers (Sedek et al., 2015). In addition the short suras are easier to be memorized.

The *Amokhtah technique* is from India and Pakistan. It is less popular among tahfiz institutes in Malaysia as students only do revision depends on their mood (Azizah,

2012). However, it is quite important technique to be practiced to ensure the students still remember the previous chapters those had been being memorized even though they had been finishing memorization of the whole 30 chapters (Abdul Hafiz et al., 2005). The example of tahfiz institutes that practice this memorization technique is Madrasah Tahfiz al-Quran Miftahul Ulum and MQKB (Sedek et al., 2015).

Turkish system technique is from Turkey. The Tahfiz Al-Quran Darul Tuba (TADT) which is located in Tangkak, Johor renowned for the use of this memorization technique. The *Turkish system technique* is introduced to the students so that they are not feeling bored as the technique does not focus to a certain chapter for a long period of time (Abdul Hafiz & Norhanan, 2010). In efforts to preserve the previous memorization of the Quran verses, the TADT conducts examinations which are called *imtihan syahadah*. Only a part of the students sit for the *imtihan syahadah* who aim to improve the quality of recitation and memorization. Thus, the *imtihan syahadah* is used as a method to enhance the quality of the memorization through the *Turkish system technique* (Abdul Hafiz & Norhanan, 2010).

The table 2.1 shows the summarization of the Quran memorization techniques those are popular in Malaysia.

Table 2.1: Summarization of the Quran Memorization Techniques

No	Technique	Implementation	Target	Founder
1	*Jibril Technique*	Memorize 3 verses per day Effective time: 30 minutes before Fajr (*Subuh*) Procedures: 5 minutes read until fluent 15 minutes memorized 10 minutes exercise Repeat 3 times before, during and after pray	Individuals those have many commitments	Mohammad Asraff Ayob Al-Hafiz
2	*Al-Huffaz Technique*	Procedures: Read until fluent the verse that will be memorized. Eg: Read 10 times by looking to *Mushaf* Recite the verse while looking to the *Mushaf* 5 times then recite again while close the *Mushaf* 5 times until the recitation up to 60 times Every recitation of verse must be followed by jotting down the repetition using tally method Increase the repetition of memorized verse within 60-200 times until embedded in subconscious mind	Children	Dr. Mohd Shafie Md. Amin
3	*Sabaq Technique*	• A new memorization of Quran verse is recited in front of teacher • Memorize 1 until 2 pages per day. Teacher will record the total verses that had been being memorized on that day • Time: after Fajr prayer	Tahfiz students	Tahfiz institutes

4	*Deobandy Technique*	For beginners the 5 last chapters of the Quran are memorized first then followed by the *sura Al-Baqarah* The chapter 30 will be memorized first followed by the chapter 29, 28, 27, and 26. Then, the memorization is continued from the first chapter until 25th chapter	Tahfiz students	Pakistan
5	*Amokhtah Technique*	Emphasize on the previous memorization of Quran verses. Eg: If the student had memorized five chapters, he will revise the 1st chapter today, then the 2nd chapter tomorrow, the 3rd chapter on the day after tomorrow, and the 4th chapter on the day after. The students are advised to do revision on the previous memorization of Quran verses after Dhuhr prayer (*Zuhur*) before beginning memorize the Quran verses (SAHO, 2015)	Tahfiz students	India and Pakistan
6	*Turkish System Technique*	Memorization of the Quran verses is begun from the back sheet of every chapter. It starts from chapter 1 on the first day, then chapter 2 on the second day, and onwards until the 30th chapter.	Tahfiz students	Ottoman Empire, 1299-1923 A.D

2.4.5 Existing Memorization Tool for Students with Autism

With the use of technological teaching aids, learning process will be more effective (Roblyer, 2006). In line with the technology advances, the use of technological teaching aids will have many great benefits to the education sector (Maimun Aqsha et al., 2009; Wan Malini et al., 2010). These kind of teaching aids are also useful in learning process especially for the Generation Z and Generation Alpha as they are very much exposed and interested with those various gadgets available in the market (Wan Noor Hazlina & Kamaruzaman, 2009b). It is also very much obvious that young people and children nowadays mostly play game applications found in the gadgets. Thus, if the use of technology and gadgets are exploited strategically in the education sector, it will help the youngsters to easily grasp the teaching delivered by the teachers in school (Mustafa & Cullingford, 2008; Roblyer, 2006).

Designing technology applications specifically for the HFAs is rather a new invention that is increasingly gaining attention (Porayska-Pomsta et al., 2012). There are also apps or tools developed to facilitate memorization in learning among the autistics. The table 2.2 below shows some reviews of existing apps those assisting the children with autism in memorization.

Table 2.2: Apps those facilitate memorization in autistics

No	Apps/ Tools	Functionalities	Platform	Reference
1	Bag Game	• Able to play with others • Level of difficulty depends on age • Enable user to upload images from their device • Facilitate turn taking, question asking, theory of mind development, verbal development, and visual memory.	iPad iPhone	(Meghan Graham, 2015)

2	Autism Speech DiegoSays	• Enhance the children's attention in learning of words. • Rewards are given as encouragement.	Android	(Moore & Calvert, 2000)
3	Autism Learning Games: Camp Discovery	• The learning games include Objects, Shapes, Emotions, Colours, and Community Helpers. • In order to gain rewards, the children required to memorize the things they learnt to answer the assessment correctly.	iPad iPod iPhone	(Miyake, 2014)
4	Circles - Memory Test	For each new level, a circle is added. The children need to decide which circle is currently added.	iPad iPod iPhone	(Schug, 2011)
5	ABC, Talk with Me!	• Learn letters and read. • Improve the children's memory and attention.	Android iPad iPhone iTouch	(Smykovsky, 2015)
6	Communication Toolbox	• Before an assessment is given, the children are taught few functions of common items and its environment (when use the item). • During assessment, the children are presented with a room and they need to match the associated items to the right area.	iPad	(Sachlis & Carpentier, 2015)
7	LetterSchool	• Learn to write uppercase and lowercase letters and how to pronounce them. • Writing assessment to test memory.	Android iPad iPhone iTouch	(Sanoma Media, 2016)

In teaching the Quran for typical students, an example which can be referred is through the research by Wan Malini Wan Isa, Fadhilah Ahmad and a group of researchers from the Universiti Sultan Zainal Abidin (UniSZA). They studied the development of multimedia courseware for the purpose of Quran class, *Kelas Pengajian Al-Quran and Fardhu Ain* (KAFA) (Wan Malini et al., 2010). Various innovative elements were adapted in the courseware including the improvement of the user interface design. Other examples of technological teaching aids that are commonly used by teachers to teach

the typical students such as Quran-in Word (Maimun Aqsha, 2009), Microsoft Power Point slides, Liquid Crystal Display (LCD) projector, video clips, and mind map software (Wan Noor Hazlina & Kamaruzaman, 2009b).

However, in teaching the Quran to the HFAs especially in memorizing the Quran verses, such technological teaching aids those fit their needs are difficult to be found. After doing some reviews of the existing memorization tool for the HFAs' use, it can be inferred that none of the Quran memorization tools developed specifically for this community. If the apps or tools available, it might not be published and are only used for a small group. Therefore, there should be technological teaching aids specifically developed to suit the use for them (Ploog et al., 2013) specifically in memorizing the Quran verses.

In this research study, during the preliminary study to observe the Quran memorization technique practiced by the HFA students, a few existing technological teaching aids those commonly used by typical individuals will be used to assist the HFAs memorize the verses of Quran as Quran memorization tool which fit the needs of the autistics were difficult to find.

2.5 Living Technology VS EVLIT

What are the differences between the living technology and Evolving Living Technology (EVLIT)? In order to understand the differences, the description of each terminology will be explained below.

2.5.1 Living Technology

Living technologies are recent technology that concerned by researchers and are expected to give vast contribution to the society as it shares the basic features of living system includes self-assembly, self-organization, adaptive complexity, evolution, and intelligent (ISSP, 2013). There are various examples of living technology such as an experiment of synthetic biology leads to the production of living systems from scratch, ICT systems communicating like natural living systems shares information across the World Wide Web, appliances designed to perform household duties, and assists the autistics to socialize by inventing companions for them.

2.5.2 Evolving Living Technology Theories and Strategies

Evolving Living Technology (EVLIT) is a future ICT which is superior to the recent living technology (CORDIS, 2011). It adopts the features of living organisms such as the computational and self-adapting. The invention of a system using the EVLIT requires for composition of embodied entities physically and chemically which then shows the properties of non-functional requirements such as scalability, evolvability, adaptability, self-reproduction, self-construction, self-organization, and robustness. Building the ICT systems using the EVLIT gives opportunities to the software developers to deal with the insurmountable problems including the software reliability, difficulty and specificity in design and development of a system. This is due to the EVLIT itself which offers to build living technologies by using biological evolution principles to ensure the information are organized as in systems of physical entities.

In order to create a system using the EVLIT, few approaches are suggested to embody the evolution. There are five approaches to be chosen by software developers to implement on their invented living technologies (Boch, 2011).

First, the living technologies are built up with nano-mechatronics to perform a better functionality of self-replication without the need for chemical reactions. This approach was determined by studying the artificial self-replicating systems in simulation and physically represented, and utilizes bio-physical mechanisms.

Second, biological information encoding principles are used in developing the living technologies. It involves the combination of chemical reactions to have new compounds and associations in chemical systems. Then, it can be improved at the electronic parts through programmable means. It differs from the first approach which chemical reactions are not involved in producing an EVLIT.

Third, in solving an issue of complexity at the information processing parts, it can be organized by bio-technologies. Thus, the operation of cell projects and cellular programmability are more efficient and effective.

Fourth, the abilities of sensors and actuation of naturally evolved life forms are integrated in producing bio-hybrid systems which enhance the robustness, flexibility and scalability.

Fifth, the combination of all the above approaches would integrate bio-chemical and mechatronic autonomous systems. This approach would be denominated as bio-hybrid and is believed to give short and long term success for system developers.

According to a report of the Future and Emerging Technologies (FET) Consultation Workshop by European Commission, Directorate-General Information Society and Media (Boch, 2011), it stated that a research or study those involves living technologies development today would benefit much by adopting the top-down and bottom-up technologies as these technologies may be widespread used in the future. The bottom-up approach as mentioned in the first approach is more programmable and controllable those enhance the integration between the components of a system while the top down approach as explained in the second approach leads to independent as the system more self-assembly.

2.5.3 Existing EVLIT

Based on the report above, there were a number of participants who involved in the workshop. Their recent articles were reviewed to know how they applied the EVLIT in their proposed system.

2.5.3.1 Unsupervised Learning using Neural Network-based Computing

Christian Gamrat and his colleagues proposed a new design approach for more adaptive electronic systems. Referring to the article (Querlioz, Bichler, Dollfus, & Gamrat, 2013), they used memristive devices to provide a region in a spiking neural network. Thus, the specific physics of the neural network could be utilized and allows customizing the neurons' threshold according to a homeostasis-type rule. In their proposed design, system level simulations together with a model of the memristive devices' behaviour were presented which the comparison of the performance between the proposed new design approach and the traditional supervised networks of identical complexity were displayed.

2.5.3.2 Perform Complex Nano-scale Chemical Tasks Autonomously

Research done by John McCaskill and his colleagues was to enhance the computation systems to perform self-governing complex nano-scale chemical tasks through combination of self-constructing chemical systems with electronic computation (Wagler, Tangen, Maeke, & McCaskill, 2012). The process took place in the Field Programmable Chemistry with the existence of electrodes and latched voltages which produce electric fields. These medium would transmit the chemicals across the hydrodynamic barriers. Although the electric fields nonsexist, the chemicals were still transmitted but slow diffusional interchange as microfluidic domains are independent. Their design of electronic chemical cells played roles of actuation and sensor networks as were introduced in developing an EVLIT.

2.5.3.3 Number of Robots and the Environment Size Affect the Evolved Behaviors

The aim of the research by Nicolas Bredeche in his article (Bredeche, 2014) was to examine that the different quantity of robots and size of the environment would result to different rate of evolved behaviours. In order to prove the hypotheses of biological mechanisms, he setup experiments with three different conditions (change the number of robots and the environment size simultaneously for every condition). The experiments had proven his hypotheses that the population size of the robots may affect the results of evolution.

2.5.3.4 Collective intelligence in a Swarm of Microrobots

According to the research by Serge Kernbach and his colleagues (Kernbach et al., 2013), a simple form of collective decision-making among microrobots could be

reached as honeybees behave towards the thermotactic aggregation. They used different experimental setups with different number of robots, area of the arena, swarm density, and the intensity of light spots. Their research resulted to success when the smaller mesoscopic-scale systems (limited swarm) adapt to perform rational decision-making for a small energy income.

2.5.3.5 EMotional Artificial Neural Network (EMANN)

A model of neural system had been being presented in a research done by Thomas Schmickl and his colleagues (Thenius, Zahadat, & Schmickl, 2013). They proposed a different model of neural system by implementing artificial emotions in the artificial neural networks (ANN). The findings of some studies regarding the biological and biochemical processes in neural cells of animals and humans, then emerged to the idea of proposed system, EMANN.

Each of the research above presented with different approaches in developing the EVLIT. Even though the fifth approach for the purpose of developing the EVLIT is expected to give a better performance, this research study has its research limitation. Thus, the approach are selected would depend on the objectives of the research study. Once the fourth approach is chosen to be adapted in the proposed system, the features of sensors and actuation could be understood further in the neurofeedback training theories as explained in the next section.

2.6 Neurofeedback Training Theories

Neurofeedback training (NFT) is defined as brainwaves biofeedback (Hammond, 2007). The brain function is directly trained to function more efficient through operant

conditioning procedure (Coben, Linden, & Myers, 2010) which monitoring devices are used so that the moment-to-moment information about individuals' psychological state is recorded (Allison, Dunne, Leeb, Millán, & Nijholt, 2012). NFT is also introduced with the use of two electrodes those placed on the scalp and put on the earlobes. This is how the brainwave signals are monitored by computer during training. The brainwaves detected are known as electrical patterns (Jacobs, 2005). These electrical patterns are measured and stimulate the audio, visual or combined audio-visual feedback on the computer screen (Vernon, 2005). During the training, it is necessary for therapist to monitor the patient, so that they are sitting behind the patient with monitoring computer without interrupting the biofeedback.

In fact, a person would not be able to control their brainwave patterns as this situation is lack of their awareness. However, with NFT, brainwave patterns those appeared on the computer screen would influence a person to change their brain function performance with continuous feedback and practice, as well as expertise's assistance (Hammond, 2007). This training procedure work as brain has its unique characteristics which are adaptable and capable of learning. The brain makes adjustments when information about how to function and respond are available.

In a research conducted by Thalia Fernandez and her colleagues (Fernández et al., 2007) had shown that individuals with difficulties managed to change the electroencephalogram (EEG) when given NFT in two months compared to a placebo-control group with no EEG changes. NFT is said as an alternative treatment to these disorders instead of the medicine treatment (Allison et al., 2012).

Instead of using medication as a treatment for ADD/ADHD, neurofeedback is seen as an effective and side effect free treatment. It also shows greater improvements

compared to Ritalin if without continuously consuming those types of drugs (Monastra, Monastra, & George, 2002) and the improvements shown in an individual could sustain on two years follow up (Becerra et al., 2006). It is vitally important to know that the practices of NFT are not only experimental, but with a well validated neurofeedback, it is now ready in healthcare services. Although a long run treatment with neurofeedback usage would very cost, the practitioners would bear with it rather than the expense in drug treatment (Hammond, 2007).

Even though NFT is seen better than medication treatment, there are also mild side effects if not perform correctly (Hammond, 2007; Hong & Lee, 2012). For instance, the patients may feel exhausted, anxious, difficult to sleep, feel dizzy, and annoyed. However, those feelings does not lasting long enough after a treatment session. In order to continue the session and eliminate those feelings, the therapist may alter to the different training protocols even after the patient mention about the discomforts.

A good quality of NFT can be ascertained through thorough preparation. NFT expertises are expected to be the person most knowledgeable about brain function rather than only proficient in handling the equipment and software. Independent practitioners who are going to have their own mental health services and concentrate to the use of neurofeedback in treating patients should be licensed and prepare insurance plans for various conditions. If practitioners taking for granted about this, the brain function assessment using neurofeedback is classified as incomprehensive (Lubar & Shouse, 1976, 1977). The treatment may cause negative effects as well as gives ineffective results. For person to be trained, it is not proper by simply examine their brainwaves pattern without knowing their clinical history (Hammond, 2011). They may receive neuropsychological or psychological testing at first as behavioral patterns are inappropriate indicators to grouping them in a few categories related to brain function

(Hammond, 2007). Furthermore, the selection of neurofeedback equipment is also playing a big role in ensuring comprehensive testing. In the next section various types of NFT will be described further.

2.6.1 Neurofeedback Training and Practices

The basic knowledge about the brainwaves is vitally important to understand. The Table 2.3 explains about the type of brainwaves detected when using neurofeedback.

Table 2.3: Type of brainwaves

Type of brainwaves	**The range of brainwave**	**State of mind**
Beta	Above 13 Hz Small and faster amplitude (magnitude)	Gives full concentration and enthusiasm in an intellectual activity.
Alpha	8 – 12 Hz Slower and larger amplitude (magnitude)	A bit disengaged in an activity. In relaxation and free from tension and anxiety.
Theta	4 – 8 Hz	Inefficiency. Subconscious like between waking and sleep.
Delta	0.5 – 3.5 Hz Slowest and highest amplitude (magnitude)	Falling asleep. Go off line. Associated with learning disabilities.

There are varieties of neurofeedback used in clinical researches. The selection of neurofeedback depends on clinicians' expected results (Hammond, 2007). The use of quantitative electroencephalogram (QEEG) in **Live Z-Score Neurofeedback training** is a current method (Hammond, 2011) and is said will give a comprehensive testing. At the end of the session, the data collected from electrical activity are compared with the

normative database to get know either the trainee's brain functions normally at his age or vice versa. There are 19 or more electrodes placed on the scalp. It will take about 1 ½ hours to complete a session (Hammond, 2007). Previous studies those involved the Live Z-Score Neurofeedback training are such researches conducted by (Hammer, Colbert, Brown, & Ilioi, 2011) in giving treatment to individuals with insomnia, and research by (Collura, Guan, Tarrant, Bailey, & Starr, 2010) with the sound and video feedback then resulted to multiple targets based on the normative database.

Another neurofeedback called LENS is **Low Energy Neurofeedback System** which is developed by Dr. Len Ochs (Hammond, 2007, 2011; Larsen & Hartmann, 2006; Ochs, 2006). LENS helps trainee's brain become more flexible and self-regulating as it depends on dominant brainwave frequency from moment-to-moment. Its feedback is very small. It is simply used by holding a cell phone to our ear and only takes about 1-7 seconds to capture the electromagnetic signals (output). LENS would produce faster results rather than traditional neurofeedback (EEG Neurofeedback) and it is suitable to be used in training kids, people those have less motivation, do not have impulse control or stamina. D. Corydon Hammond (Hammond, 2010) has reported that LENS showed its effectiveness in anger control and brain injury. In other controlled study, Stephen Larsen (Larsen, Harrington, & Hicks, 2006) did further research on a large sample of spectrum of disorders about the effectiveness of LENS.

The other form of neurofeedback is **near infrared hemoencephalography** and **passive infrared hemoencephalography (HEG)**. Its function is to help modifying cerebral blood flow by increasing it at deficient areas (Toomim & Carmen, 2009). It happens when near infrared HEG detects changes in cerebral oxygenation then the information (changes in oxygenated and deoxygenated blood) in the form of chemicals are sent to optical diodes. The other benefit of HEG, it also supports patients suffer from migraine

(Duschek, Schuepbach, Doll, Werner, & Del Paso, 2011). Studies those have been carried out such as yet unpublished, research by Coben (Coben, 2006), with three trained groups classification. The three groups were assigned as (i) near infrared HEG group, (ii) passive infrared HEG group, and (iii) wait-list control group. Toomim and his colleagues (Toomim et al., 2005) conducted research upon individuals with brain disorders to prove that HEG is able to improve sustained attention through the oxygenation increment in a selected brain tissue.

Slow Cortical Potentials (SCPs) is a type of neurofeedback training that also benefits patient with migraine (Kropp, Siniatchkin, & Gerber, 2002). When patient suffers from migraine or epileptic seizures, the cortex is electronegative then shifted in direct current potentials to create positive slow cortical potentials (electro-positive) (Hammond, 2011). Slow cortical potentials training use one electrode that is placed on the top of head and another one is put behind each ear. The current researches in using slow cortical potentials in NFT could be seen through research by (Strehl et al., 2006) and (Heinrich, Gevensleben, Freisleder, Moll, & Rothenberger, 2004) upon children with attention-deficit/hyperactivity disorder. Heinrich reported that the symptoms in ADHD were reduced about 25% after the slow cortical potentials training.

Another kind of QEEG is **Low Resolution Electromagnetic Tomography (LORETA) Neurofeedback training**. The use of LORETA needs larger workforce preparation where 19 electrodes should be put on the scalp for every session of training. According to the research done by Dr. Rex Cannon and Dr. Joel Lubar from University of Tennessee (Cannon & Lubar, 2011), LORETA is seen have capacity to the outcomes betterment especially in difficult cases as well as the possibility to shorten the period of treatment. In a research conducted by (Frei et al., 2001), LORETA was used as an approach to discover the generators of EEG frequency components.

A type of NFT that is very complex of functioning is **functional Magnetic Resonance Imaging (fMRI)** (Hammond, 2011). Functional MRI neurofeedback able to examine ones' brain function extensively which is at deep subcortical areas of the brain. However, this type of NFT is very costly equipment preparation including the day-to-day treatment. Its operating costs almost $1 million or more. Therefore, the use of functional MRI neurofeedback is not a practical idea in clinical treatment either in today's era or in the future. In a different view, functional MRI is still in use as research done by (Johnston, Boehm, Healy, Goebel, & Linden, 2010) about to prove that it is convenient in emotion networks and the use of it is highly recommended in therapeutic process.

2.6.2 Neurofeedback Training and Attention Issues

NFT is applied to treat patients with various problems for instance patients with severe epilepsy, brain injuries, sleep disorders, stroke, anxiety in adult children of alcoholics, cerebral palsy, and autism. Besides of dealing with those difficulties, NFT is also playing its important role in enhance performance to the highest level such as cognitive, attentional, behavioral, and IQ level (Hammond, 2007; Leins et al., 2007) especially in assisting the patients when learning.

The attentional system in autism had been discussed in previous section and we acquire understanding that attention deficits are the main impairment in autism. Individuals with autism are also showing no deficits in visual continuous performance tasks compared to auditory continuous performance tasks. In the next section, previous studies will be reviewed, on how the researchers bring the advantage of autistics' strengths in selecting the approaches to be implemented in the NFT in order to enhance their attention performance. The adapted approaches in NFT play a big role to ensure the beta

brainwaves activity increased while the alpha, theta, and delta brainwaves are decreased.

2.6.3 Neurofeedback Training and High-functioning Autism

NFT have been proven assisting people with autism in evaluating their condition as well as improving the symptoms of attentional deficits such as auditory and visual attention and IQ points (Hammond, 2007, 2011; Lubar, 1995; Thompson, Thompson, & Reid, 2010). However, the effectiveness of neurofeedback treatment will long-lasting in individual with autism if they are not exposed to drugs abuse and head injury which will lead to negative alter brain function (Monastra et al., 2002).

NFT is a non-medical treatment to enhance performance in healthy people for instance in mathematics, motor skills, and creativity. Moreover, the more important is in education aspect. Those people suffer from attentional deficits such as Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) are also given training using neurofeedback to increase attention span in order to improve their academic performance.

Realizing that NFT demonstrates significant improvements in autism symptoms and behaviors, these technologies are often used by researchers and practitioners to prove its effectiveness in assisting students with Attention-Deficit/Hyperactivity Disorder (ADD, ADHD).

In different studies, the approaches used in implementing the NFT for autistics are slightly different from each other. Some of the researchers did NFT assessment through visual or auditory feedbacks approaches, or other approaches such as verbal and motor

response to assist the autistics train the brain functions to function better (Allison et al., 2012) with various of rewards system introduced. Several documentations of previous studies those related to the approaches used in NFT to enhance the autistics' attention performance were reviewed as in table 2.4.

Table 2.4: Approaches Used in NFT

Year/ Reference	**Research Objective**	**NFT approach(s)**		**Summary of Findings**
(Saini & Agarwal, 2015)	To improve brain abilities in the individuals' having brain issue.	Rewards are received when subject successfully self-direct the brain waves to accomplish good performance in the game.	• Video game with audio or visual or combined audio-visual feedback • Rewards	After series practice over various Neurofeedback sessions, sought brain abilities can be upgraded.
(Wigton & Krigbaum, 2015)	To assess the viability of 19-channel z-score Neurofeedback (19ZNF) in a clinical setting among ADHD.	Fed back to the patient with simple non-movie animations together with discrete auditory reward tones (Operant conditioning and the attention task working simultaneously)	• Brainmaster Flashgame visual feedback • Rewards	19ZNF enhanced attention.
(Steiner, Frenette, Rene, Brennan, & Perrin, 2014)	To assess the adequacy of 2 PC attention training systems regulated in school for youngsters with attention-deficit hyperactivity disorder (ADHD).	A dolphin character swims down to the base of the sea to gather coins from a treasure chest, and the child gains points. In the event that the child is distracted, the dolphin swims back up to the surface of the sea.	• Video game (Moving character) with audio and visual feedback • Rewards	Enhancements in attention and executive control, demonstrating that this intercession holds guarantee as an alternative treatment for youngsters with ADHD.
(Mandryk et al., 2013)	To ensure an appealing play experience that will retain a subject's interest.	Graphical overlay is presented on top of a running game that clouds the fundamental game when the subject is	Biofeedback games with visual feedback (altering display	Ready to draw in the subject's enthusiasm more than a long haul while playing the

		not in the craved physiological state.	graphics)	game.
(Hong & Lee, 2012)	1) To examine impacts of NFT in a neurofeedback group. 2) To explore contrasts in effects on attention tasks with the brainwave activity produced.	Subjects are required to select any one game, Painting, or Making a cup, or Bending a spoon, or shooting an arrow. When the game successfully completed, another bonus game would be offered as a reward.	• Game with audio (beeps) or visual (colour changes) feedback only if the game successfully completed • Game with motor response • Rewards	The NFT group showed significantly improved scores on the all tests (CCTT-2, SCWT, and Digit Span tasks).
(Kouijzer, de Moor, Gerrits, Congedo, & van Schie, 2009)	To explore the hypothesis: NFT decreases theta activity while remunerating low beta activity, as per the standard ADHD treatment protocol.	**Visual selective attention**: Subject needs to react to one specific character on the PC screen while disregarding different characters amid 5 min. (measured by the Continuous Performance Test (CPT)). **Auditory selective attention**: Subjects need to react to sets of 3 beeps while disregarding arrangements of 2 or 4 beeps. (Measured by the Test of Sustained Selected Attention (TOSSA)). **Verbal response inhibition**: Subjects need to peruse out loud at the earliest opportunity. (Assessed by the Stroop test). **Motor response**	• Activity with visual and audio feedback • Activity with verbal and motor response	Noteworthy change in attentional control, cognitive flexibility and goal setting were noted for the subjects.

		inhibition: Based on the quantity of commission errors. (Inhibition was assessed with the response inhibition score (RIS; range 0–100) of the TOSSA).		
(Groom et al., 2010)	To research impacts of motivation on neural correlates of response conflict and attention in ADHD.	A go/no-go paradigm was used. Subjects were required to give attention to a central point of stimuli within 100 msec. When a frequent "go" stimulus (green aliens) popped up, subjects were instructed to press the button, or conversely to cease from reacting to an infrequent "no-go" stimulus (black aliens). Subjects would pick up 1 point for each convenient reaction or lost 1 point for each slow or missed reaction.	• Activity with visual feedback and motor response (quick response to the right answers) • Rewards	The motivational incentives were viable in improving attention in ADHD.

2.7 Brainwave reading headset

The tool that used to record brainwave data is called EEG (electroencephalograph) device (Katona, Farkas, Ujbanyi, Dukan, & Kovari, 2014) or brainwave reading headset. Commonly, the use of brainwave reading headset depends on the purpose of each research or medical. Each type of the brainwave reading headset is invented to function slightly different. Nowadays, there are various brainwave reading headset available on the market such as Emotiv Epoc headset (Duvinage et al., 2013), EMOTIV

Epoc+, EMOTIV Insight (EMOTIV, 2011), and NeuroSky MindWave headset (Neurosky, 2014). In this research project, the NeuroSky MindWave headset was used.

2.7.1 NeuroSky EEG biosensor technology

The NeuroSky MindWave headset (Mindset) can be used for various purposes such as games, wellness, and education, which benefits the researchers and system developers. The characteristic features resemble other brainwave reading headsets (NeuroSky, 2014). Basically, this type of headset gives outputs of NeuroSky eSense meters which display the attention and meditation level. For the purpose of this research project, the NeuroSky MindWave Mobile was used as it is a type of mobile compatible device and it could measure the attention level of the users. It is also can be used in NFT with type Slow Cortical Potentials which benefits patients among children with attention-deficit/hyperactivity disorder. Besides that, the NeuroSky ThinkGear ASIC chip also was used to connect the electric impulse alternations generated by users' brainwave to the developed system or apps. The example of researches those used the NeuroSky MindWave headset as measurement tool to record the attention level are explained in the next section.

2.8 Existing Framework for Developing Learning System using Neurofeedback

Previous researches of neurofeedback were reviewed to analyze the frameworks which fit the necessity to develop a learning system. The selected existing frameworks below were reviewed and discussed further.

2.8.1 Yu-Chen Kuo and Tsu-Yang Wang System Framework

Yu-Chen Kuo and Tsu-Yang Wang in their study (Kuo & Wang, 2013) assumed that the learning emotions are the key factor of the learners' achievement. When the learners are found in the concentrate mode and out of feeling depressed or distracted, their learning performance was improved. Thus, learning emotions which involves the attention would play the roles in the learners' learning performance.

Based on the learning emotions together with the use of NeuroSky MindSet to monitor the learners' brainwave while learning, they proposed a procedure of an experimental group as shown in figure below to encounter the attentional deficits appeared in learners.

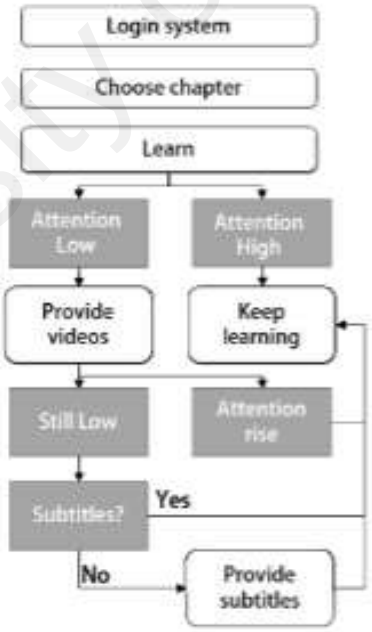


Figure 2.4: Yu-Chen Kuo and Tsu-Yang Wang System Framework

The learning emotions are handled during the learning session. The learner's attention is identified by the MindSet. If the learner's attention low, the system will provide videos so that the learner's attention gets back to the concentrate mode. The learners are

continuously provided with anything to ensure they are in a good learning emotion to perform an effective learning. Watching videos is one of the favourite activities of the autistics (Brok & Barakova, 2010). They used the method of watching videos for the purpose of controlling the emotions during learning.

2.8.2 Luca Szeglets and Bertalan Forstner System Framework

According to Luca Szeglets and Bertalan Forstner (Szegletes & Forstner, 2013), for a better performance in learning, an educational game development should consider the reward manipulation as learners aim for achieving rewards when solving tasks through games. The self-rewarding and feedback-based framework was introduced for game developers to raise new ideas in developing adaptive and creative games. When the learner responds to the gameplay, reward appears as a motivation to do better in the next actions (solving tasks).

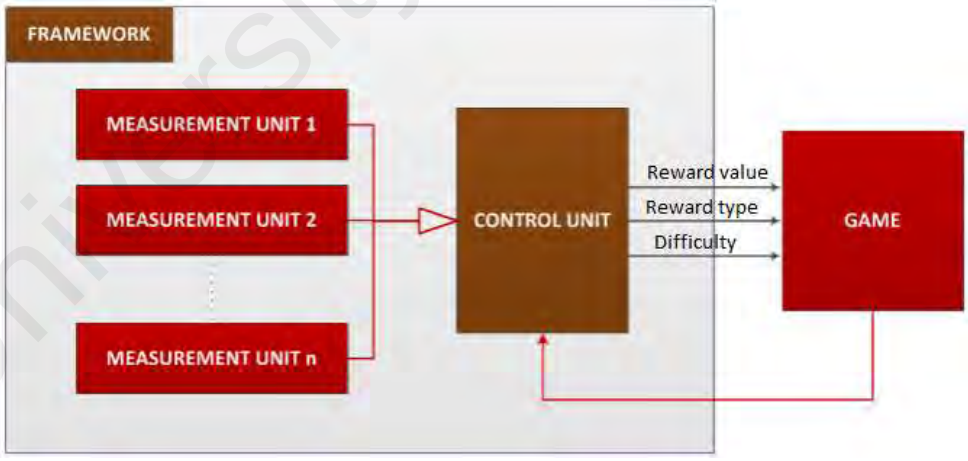


Figure 2.5: Luca Szeglets and Bertalan Forstner System Framework

In accordance with their suggested system structure, the framework is divided into two parts which are measurement units and control unit. The measurement unit plays its role to attach devices to the framework. As developing the educational neurofeedback game, the main device such as the Emotiv headset is needed to measure the brainwave activity

where the attention levels are measured, as well as the driver installation for collecting the data from the EEG device on mobile devices. The difference in control unit, it produces the rewards for the game interface based on the prepossessed data (from measurement units). Aiming for betterment in learning performance and for a smooth attention control, the manipulation of outputs should be put into consideration. The control unit would produce three different outputs which are the *difficulty*, the *type of the reward*, and the *value of the reward*.

Difficulty: Based on the game concept, for the following next game sections (game levels), the difficulty increases. The difficulty of the next game section is according to the psychological and mental state of the learner as calculated in the framework.

Type of the Reward: The educational game would provide various types of reward as the learners' interest are different according to their different ages. Before starting the next gameplay section, the type of reward initialization should take place.

Value of the Reward: The accumulated rewards are important. As game level increases, the rewards value also increases. The game events generated by the game then sent to the framework for the next calculation of the reward value.

The system framework introduced by Yu-Chen Kuo and Tsu-Yang Wang also applied the same method of self-rewarding adapted in this game system structure. The videos provided appears as a motivation which is the purpose of the rewards system. The concentration towards learning session gains as motivation given to the learners.

2.8.3 Kavitha P Thomas, A. P. Vinod, and Cuntai Guan System Framework

According to the study by Kavitha and colleagues (Thomas et al., 2013), they proposed the design of the game with the Brain-Computer Interface (BCI) system concept incorporating with three entities which are the learner's selective attention, sustained attention and memory skills. The attentional deficits are not only related to the psychological issues in an individual but it is the combination of those entities to reflect one behaviour (Loe & Feldman, 2007). The following figure shows the proposed neurofeedback BCI system.

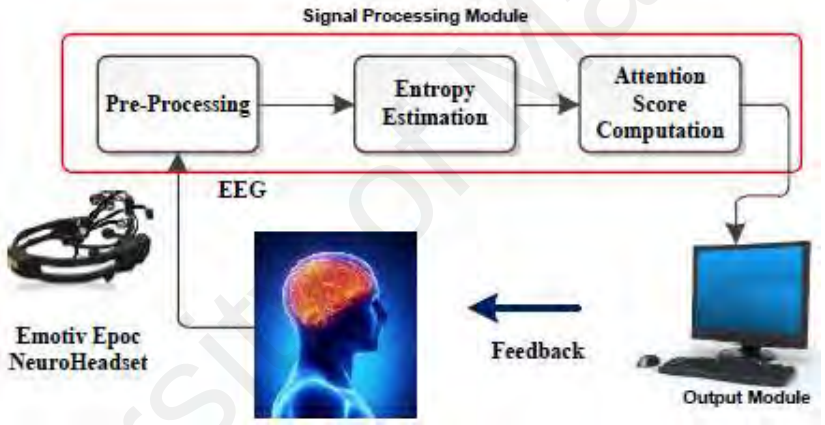


Figure 2.6: Kavitha P Thomas, A. P. Vinod, and Cuntai Guan System Framework

The design proposed consists of four modules which are described as follows:

EEG acquisition module: At this stage, the learner's brain activity is recorded by using the wireless emotiv headset. The EEG signal is then measured for the preliminary processing before sending it to the computer software.

Signal processing module: This module is composed of three sub-modules which are pre-processing unit, entropy estimation unit and attention score computation unit. Through these modules, the EEG signal is going to undergo further processing,

measures the complexity of the signal to simple entropy, and computes the attention score.

Output module: At this stage, the computed attention score is manipulated for the Graphical User Interface (GUI) which is the output module. The incorporation between the essential components: gaming protocols; control mechanisms; and the game interface would form the neurofeedback game.

System controller: The core role of the system controller is integrating all the modules for functioning according to its designated protocol.

The three entities suggested above are highly adaptable to this game system. The learner's working memory stores a specified amount of information. At this condition, with the ability of selective attention allows the learner to give attention to a particular stimulus (familiar stimulus) even though various stimuli are presented simultaneously. It may happen whether the learner in a state of conscious or subconsciously. The way stimulus are presented affects the ability to sustain attention (Parasuraman, 1979).

2.8.4 Yunsick Sung, Kyungeun Cho, and Kyhyun Um System Framework

Learners possess different brainwave that may difficult for the game developer to design different contents of a game specifically for the use of each of them. Yunsick Sung and colleagues (Sung, Cho, & Um, 2011) in their study stated that the multi wave forms produced by different learners could be standardized into a specified signal so that each of them able to suit themselves use the same type of contents of a game. Therefore, things those they have to concern about are to do normalization and transformation of the generated EEGs for the purpose of game contents.

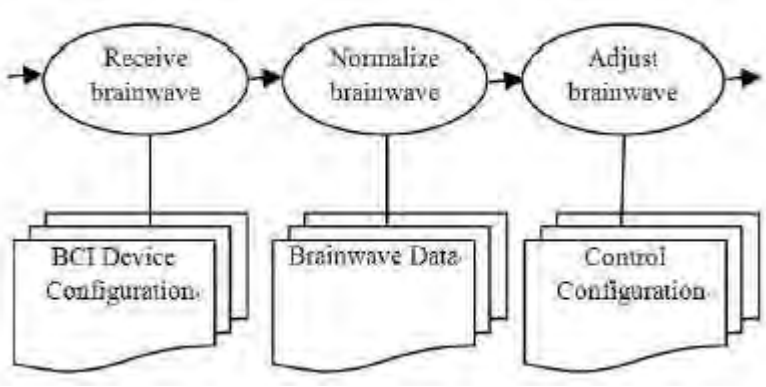


Figure 2.7: Yunsick Sung, Kyungeun Cho, and Kyhyun Um System Framework

The figure 2.7 above shows the EEG framework which describes how the brainwave is handled. The brainwave will be processed through three stages which are receive brainwave, normalize brainwave, and adjust brainwave.

Receive brainwave: Once the device is connected to the system, the signal is transformed into brainwaves through a provided method for further utilization. Then the brainwaves are transferred to the brainwave receiving stage.

Normalize brainwave: At this stage, the steps should be taken for the brainwaves to be normalized are, i) Brainwave collection step, ii) and Brainwaves change step. Brainwaves are measured and collected over a specified period before converted to similar signals through a constructed formula as in their study.

Adjust brainwave: The normalized brainwave values then adjusted according to the learner. It is difficult to generate learner's brainwaves in the right manner as each of them was evaluated in a different session. After undergo the calculation at the last stage, the signals are transferred to BCI contents (computer interface).

In comparison to the previous three reviewed system frameworks which the continuous training are given to the learners to enhance the attention performance when solving

tasks, this framework was proposed with the aim to cut cost and reduce time consuming during the game development as well as reduce training time. Therefore, they preferred to use the method of brainwave normalization and adjustment in order to do correction over the learner's brainwave. The learner's measured brainwave was standardized according to the specified measurement of the BCI contents, so that when playing the game, the device does always fit the learner effectively.

The four existing frameworks have been reviewed and it can be deduced as shown in the Table 2.5.

Table 2.5: Existing Neurofeedback Training Frameworks

No	Framework	Features	Method	Measured brainwave	Brainwave reading headset
1	Yu-Chen Kuo and Tsu-Yang Wang	To ensure the learners are in good learning emotions to perform an effective learning	Video is presented when learner's attention low	Attention and meditation	NeuroSky MindSet
2	Luca Szeglets and Bertalan Forstner	Self-rewarding and feedback-based system. Reward appears as a motivation to perform better in the educational game	The type of reward varies for different age and gender groups	Attention	Emotiv EPOC EEG
3	Kavitha P Thomas, A. P. Vinod, and Cuntai Guan	The user's selective attention, sustain attention and memory skills are required to obtain the reward points	Answering the questions based on the memorized information	Attention	Emotiv EPOC EEG
4	Yunsick Sung, Kyungeun Cho, and Kyhyun Um	To ensure the game always fit the learner by doing brainwave normalization and adjustment	Memorizing English word with the aid of cartoon images	Attention and meditation	NeuroSky MindSet

2.9 Summary

The findings from this chapter have concluded that individuals with high-functioning autism have difficulties to sustain attention for a longer term when learning. Considering their learning style, contents of the lesson learnt should be delivered visually, verbally, or physically as each of them has different learning style. In addition, the teaching aids used such as the use of familiar stimulus assist them to sustain attention.

It is not an issue to memorize the lesson learnt as the HFAs have no difficulties to memorize complex configuration as well as the simple configurations. However, it is difficult to teach the Quran memorization for them by using traditional style as it may affect the HFAs' attention. Thus, a good memorization technique and strategy would assist them in memorizing the Quran verses. According to their learning style, suitable environment should be provided for them to memorize the verses of Quran easier.

The existing interventions of the Quran education were also reviewed to see how the interventions were carried out. However, it is quite disappointing as it is very few interventions provided for the HFAs. Besides that, the existing memorization tools were also reviewed to know the contents, functionalities and their benefits for the HFAs. Most of the functionalities are good to enhance the HFAs' attention however it is difficult to find tools developed for the Quran memorization purposes for HFAs.

The descriptions about living technology and EVLIT as well as the previous studies concerning about the EVLIT also were discussed in this chapter to consider the features of the proposed system in this research study. Based on the EVLIT, this research project would apply the abilities of sensing and actuating of naturally evolved life forms which

are integrated in producing a bio-hybrid system. Neurofeedback training (NFT) is also a type of bio-hybrid system. In order to adapt the NFT concept, the previous researches concerning the NFT practices as well as the proofs that NFT improves attention of the HFAs were also described.

Finally, the existing neurofeedback frameworks and approaches used for developing learning system were reviewed to consider the use of brainwave reading headset, the approaches to be adapted, and the basic components required for developing the proposed system framework (Quran Memorization Tool).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The needs of understanding of attention performance of people with High-functioning autism, methods used in different previous studies in improving their attention performance, different techniques used in memorizing the Quran verses, as well as the effectiveness of using neurofeedback training (NFT) in enhancing the attention performance had been identified in the literature review explained in Chapter 2. In accordance with the knowledge, this chapter discusses the research methodology flow so that the objectives specified in chapter 1 would be achieved and answering the questions indicated in the problem statements section. In this chapter, the preliminary study with its outcomes also would be discussed and answering the relevance of developing the Quran Memorization Tool (QMT).

3.2 Research Methodology Flow

This section discusses the research methodology flow. In this research project, the flow of the research methodology is illustrated as in Figure 3.1. The most methods used in the field of research are Qualitative, Quantitative, or Mixed Method Research. *Qualitative research* is conducted through open-ended approach in information gathering through unstructured interviews or observations which then being analyzed by categorizing the information to view the results. Different with *Quantitative research* which requires for the close-ended approach in information gathering that is in numerical form and few instruments such as statistical analysis are needed for the

analysis to view the results. *Mixed method research* integrates the use of both the qualitative and quantitative methods in a research conducted (Creswell & Plano Clark, 2007).

This research project adopted the mixed method research which involves the qualitative and quantitative methods. Qualitative and quantitative (mixed method) were used when identifying needs for the research regarding the development of the proposed system which could assist the high-functioning autistic (HFA) students to enhance their attention performance during the Quran memorization. Literature review, interview with care givers, and observation of the HFA students are required as techniques of identifying needs for the research. Quantitative method then was practiced to evaluate the students' memorization performance during the pre-test and post-test when using the developed system. NeuroSky MindWave headset (Mindset) was used as measurement tool to record the students' attention level.

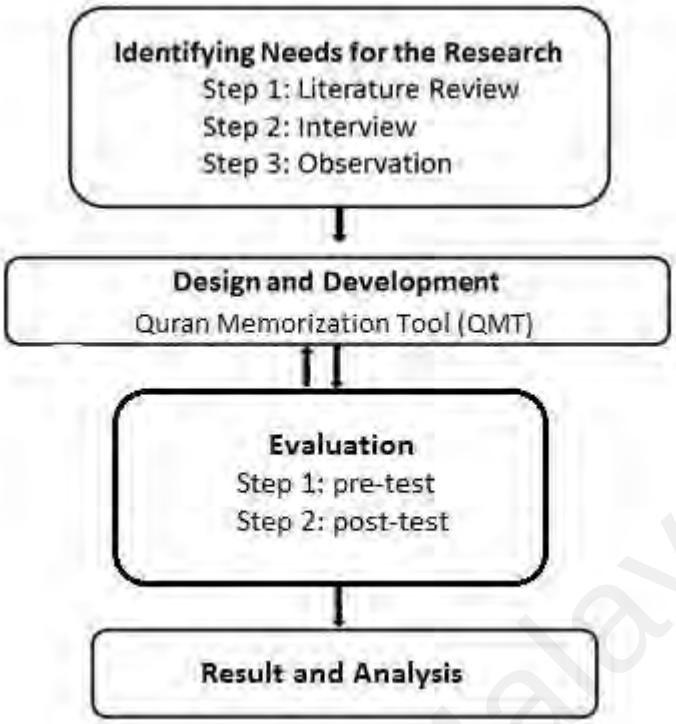


Figure 3.1: Research Methodology Flow

3.2.1 Identifying Needs for the Research

It is important to identify the needs of the HFA those able to maximize the efficiency of the system. Thus, a preliminary study is a good platform to obtain the user requirements through the literature review, interview, and observation concerning the HFAs' attention performance during memorization of the Quran verses, activities involvement when getting bored during the memorization, and inclination towards Quran memorization techniques.

3.2.1.1 Literature Review

In an effort to assist accomplishing the aims of this research, literature review is required to meet the necessities in developing the QMT which fit the needs of the HFAs. Reviews of the previous studies include; i) understanding about the HFAs' attention performance, ii) the identification of the suitable Quran memorization

techniques to be adopted in the system as the HFA requires for slightly different technique compared to typical students, iii) the approaches employed in the NFT those accommodate the criteria of the HFAs to prolong the attention span during memorization of the Quran verses, iv) the suitable measurement tool to be used in the system to capture the HFAs' level of attention during the memorization, v) and the design of the appropriate framework to be adapted in the QMT.

3.2.1.2 Interview

Other than literature review, it is important to do some interviews to the students' caregivers (parents and teachers) as well as special education experts. The requirements needed in order to develop the QMT are the understanding of the HFAs' behaviour when memorizing the Quran verses. It is referring to their inclination in doing other activities when they become bored in the middle of the memorization session. The things those important to be taken note during the interviews are the kind of activities the HFAs choose to amuse themselves when feeling bored.

3.2.1.3 Observation

This research is not complete without doing observation over the HFAs closer to empathize with their feelings and understand their behaviour when memorizing the Quran verses. This procedure would help in developing the meaningful QMT. Through the observation, the HFAs' propensity for other activities when feeling bored memorizing the Quran verses within the specified time was taken note. During this procedure, other than notes taken, the activities done by the students also were captured for further analysis. Besides that, the HFAs' attention performance (time spent in

sustaining the attention) and the techniques used during the memorization of the Quran verses also were observed.

3.2.2 Design and Development

The development of the QMT was based on the preliminary study outcomes. It covered the needs identified through the literature review, interview, and observation. The system framework would first develop before the development of the QMT. The following subsections will explain about this.

3.2.2.1 System Framework

The system framework was resulted from the literature review done in the preliminary study. It was composed of several components to develop a neurofeedback training (NFT) as a bio-hybrid system. Suitable NFT approaches were selected to be adapted in the system. The other outcomes obtained from the preliminary study (interview and observation) were also helped in developing the system framework.

3.2.2.2 Development of System

The QMT was developed based on the designed system framework. Activities of the system development include the system design, Graphical User Interface design, and the description of usage scenario. The QMT is a type of bio-hybrid system as the combination of two systems (Quran reciting system and measurement tool) which applying the concept neurofeedback training. The technology used in this system is called EVLIT. Thus, this research project expects the QMT would show the properties of the EVLIT those benefit the users.

3.2.3 Evaluation

The QMT was evaluated to test its effectiveness as an intervention that enhances the attention performance of the HFAs during memorization of the Quran verses. The evaluation conducted would base on the procedures which will be explained in the subsection below. The evaluation parts were divided into two sessions which are pre-test and post-test.

3.2.3.1 Evaluation in Pre-test

The purpose of this pre-test is to know the HFAs' attention level during memorization of the Quran verses using the QMT version 1. The evaluation of the QMT version 1 would only focus on the recitation and memorization of a specified sura (*sura al-Jumu'ah*) by displaying the texts and audio which requires only verbal response from the users.

3.2.3.2 Evaluation in Post-test

In comparison to the first evaluation (pre-test), the post-test was carried out to know the HFAs' attention level during memorization of the Quran verses using the enhanced QMT (QMT version 2). The evaluation procedures were the same as in the pre-test but the feedbacks from the users when using the QMT version 2 are slightly different. The feedbacks include visual and audio feedbacks, verbal response, and rewards. Would the QMT version 2 improve the HFAs' attention performance? It will be resulted later in Chapter 5.

3.2.3.3 Experiment Methods and Procedures

This section explains the method and procedures of the evaluation. It includes the description of participants, experiment settings, hardware and software, as well as evaluation procedures.

3.2.3.3.1 Participants

Ten students with high-functioning autism were selected for the experimental evaluation of the QMT. The students comprised of 9 boys and 1 girl. These students attend for daily or weekend Quran class at one of the Islamic center for children with special needs in Petaling Jaya; *Akademi Fakih Intelek*. They are 8 to 29 years of age. The observation done during the preliminary study proved that these students able to memorize the Quran verses. Figure 3.2 presents the age range of the participants.

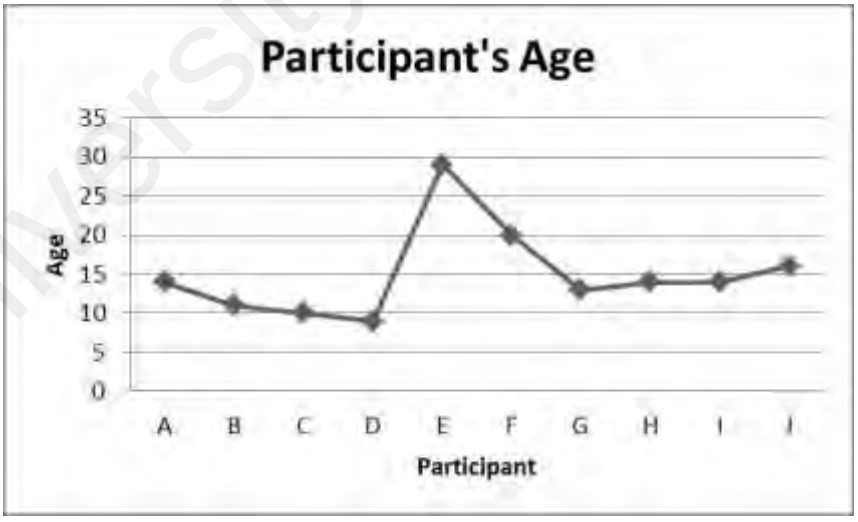


Figure 3.2: Participant's Age

Average of the participant's age is: $\frac{\text{Summation of participant's age}}{\text{Number of participants}} = 15$

3.2.3.3.2 Experiment Settings

The evaluation sessions were conducted in an office at *Akademi Fakih Intelek* with one table and one chair provided. A computer was put on the table those facing the chair. A convenient place should be used to ensure the environment is good and apart from other distraction during the evaluation.

3.2.3.3.3 Hardware and Software

For the purpose of the experiment, a video camera was used to record the participants' behaviour during the evaluation. A desktop computer was used to operate the experimental tool in which the QMT was installed in the virtual machine (VM ware) to reduce administration burden on servers. In this experimental evaluation, the NeuroSky MindWave headset (Mindset) was used as an equipment to measure and record the attention level of the participants. The Mindset was integrated with the Quran reciting system to ensure the whole system could provide visual and audio feedback, rewards as well as receive verbal response during the Quran memorization.

3.2.3.3.4 Evaluation Procedures

The participants were observed during the pre-test (QMT without visual, audio feedback, and rewards) and post-test (QMT with visual, audio feedback, and rewards). The evaluation procedures used in both tests were the same. The procedures are listed as follows:

1) The evaluation of the system is conducted in an office in the morning.
2) Participants are reciting Ruqyah (behavioral therapy using Quran) first before the evaluation.
3) When students come into the office, they sit down and take some relaxation time in a comfortable condition for 2 to 3 minutes.
4) Participants are given instructions for the evaluation.

The purpose of this evaluation is to record individual attention level while simultaneously listening to sura al-Jumu'ah. Sit down comfortably on the chair and listen to the sura. During evaluation, you should not touch the headband on your head. Please keep silent and pay attention with a relaxed mind.

5) Then, attach the Mindset on the head and start the evaluation.
6) The student listens to the *sura al-Jumu'ah* which consists of 11 verses.
7) The researcher sits in the office, controls the evaluation and keep notes.

3.3 Preliminary Study

The preliminary study was carried out within 10 months (March 2013 to December 2013). The first 7-month, the observation of the students among the HFAs was conducted as well as the interview with the caregivers of the HFAs (Parents and teachers) and special education experts. The literature review was also done until the end of tenth month. The Literature review helped in understanding the HFAs' attention performance, identifying the suitable Quran memorization techniques, the appropriate approaches employed in the NFT, the suitable measurement tool to capture the level of attention, and the most important is to identify the appropriate framework to be adapted in the system. Through the interview and observation, the HFAs' behaviour during

memorization of the Quran verses was identified. The observation was also contributed in identifying the HFAs' attention performance (in terms of time spent) and the techniques used when memorizing the Quran verses. In this section, the preliminary study describes further about the activities (Literature review, interview, and observation) in order to elicit the needs for the research. At the end of this chapter, the outcomes of the preliminary study were discussed that answering the objective 1, 2, and 3 of this study.

3.3.1 Identifying the Components of Bio-Hybrid System Framework

In identifying the components in the system framework during the preliminary study, a few previous studies were reviewed through *literature review technique* to meet the necessities in developing the QMT which fit the needs of the HFAs in memorizing the verses of Quran for a longer attention span. The different studies were reviewed in terms of the features, methods used in assisting learners in their learning improvement, the type of brainwave reading headset used, and the type of measured brainwave.

The main objective of the previous researches was to enhance the attention performance during the tasks completion. In order to achieve the objective, the researchers introduced their own methods and unique features which were adapted in the neurofeedback. These explanations can be found in chapter 2.

3.3.2 Identifying the Most suitable Technique in the Quran Memorization for HFAs

In the chapter 2, a few Quran memorization techniques those have been being practiced by the Malaysian were reviewed. The techniques those are often practiced among the communities are like *Jibril technique*, *Al-Huffaz technique*, *sabaq technique*, *Deobandy*

technique, *Amokhtah technique*, and *Turkish system technique*. It can be deduced through the Table 2.1 where it shows the suitability of the memorization techniques to the targets. Not all of the Quran memorization techniques fit the suitability of a *hafiz* (Quran memorizer) as the *hafizs* are from different backgrounds and live in different environments. It is important to choose the appropriate Quran memorization technique as it determines the success in memorizing the Quran verses (Azmil et al., 2013).

3.3.3 Interview with Care Givers of people with HFA

Interview technique is also included during the preliminary study with the caregivers of people with HFA. The interviewees of the preliminary study were parents, teachers, and special education experts. The interview was conducted to understand more about the HFAs' behaviour while learning especially when memorizing the Quran verses. Commonly, in the middle of learning session, they are easily feeling bored. Thus, through these interview sessions, the information about activities the HFAs chose to amuse themselves when feeling bored were notified. The table 3.1 below describes the details about the interviewees.

Table 3.1: Summary of Interviewees Profile

Name	Occupation	Experience	Case Study
Mr. Haris	Special education expert	7 years	Special needs students at Sekolah Kebangsaan (2) Sultan Alam Shah
Mrs. Aziah	Special education expert	19 years	Special needs students at Sekolah Menengah Kebangsaan Temerloh

Mrs. Khatimah	Teacher	2 years	HFA students at Akademi Fakih Intelek
Mrs. Norina	Parent	14 years	Lat (HFA)
Mrs. Nora	Parent	11 years	Haris (HFA)

1. Mr. Haris

Mr. Haris is a special education teacher at Sekolah Kebangsaan (2) Sultan Alam Shah. He experienced in the special education field for about 7 years in teaching children with special needs such as autism, hearing impairment, and learning disabilities. He commented some experience when teaching the autistics especially the HFAs. He commented:

"Students with autism have short attention duration. During the learning process, when the students are losing focus, they are inclined to do their favourite activities such as drawings, making origami, and reading comics. Teachers need to play their role to grab the students' focus back to the learning process using any creative ways."

2. Mrs. Aziah

Mrs. Aziah is an expert in special education sector. She experienced teaching the students with special needs for about 19 years. She succeeded in publishing a text book that assists people with hearing impairment to learn the Quran. She explained about her observation while teaching the students with autism. She explained:

"The students behaved differently when they feel bored during lesson learnt. Some students like to pace up and down, play with toys or anything those are easily to be reached. There are also students who like to paint and draw. It is almost all students with autism hard to follow all instructions from adults. It takes time to grab their attention."

Mrs. Khatimah

Mrs. Khatimah is a teacher at Akademi Fakih Intelek. She had taught the HFAs about two years. Her class was attended by three to four students. She shared her experience when teaching the HFAs. She narrated:

"These students, when they are no longer interested to listen, recite, or memorize the verses of Quran, the teachers will give break for a specified time. They are seen love to play video games, watch animation videos, or work with hand drawings"

3. Mrs. Norina

Mrs. Norina is Lat's parent. Lat was sent to Akademi Fakih Intelek to learn the Quran. Mrs. Norina experienced raising her son with autism for about 14 years. She shared about her son's behaviour. She said:

"He doesn't like to see many words when looking at a book for a long term. He likes to change to other activity after feeling bored in completing a specified task"

4. Mrs. Nora

Mrs. Nora is Haris's parent. Haris was also sent to Akademi Fakih Intelek to learn the Quran. She experienced raising her son for about 11 years. She explained some of her encounters with her son at home. She explained:

"After going through completing a task for certain duration, sometimes the task does not finish yet, then he will request to listen to the radio. If we deny his request, he will get into tantrum."

3.3.4 Observation on HFAs' Attention Performance during Memorizing Quran Verses

Other than reviewed a number of literatures about the HFAs' attention performance which were discussed in the chapter 2, an observation was made for 28 weeks during the Quran memorization session that was conducted four days in every week at Akademi Fakih Intelek. Three male and a female students with high-functioning autism were selected to be observed when learning. Inclusion criteria for the students to be selected as subject in the observation were as follows: (a) individuals with high-functioning autism; (b) not having characteristics of serious mental retardation; and (c) able to follow the classes for 28 weeks. The four students were children and teenagers of 9 to 28 years old.

Two trainers were responsible to teach and record the responses given by the students during memorization of the Quran verses within 60 minutes. The evaluation form as in Figure 3.3 was used to record the students' responses. The students were required to listen, pronounce, and finally memorize the verses of suras which include surahs in *juz' 'Amma*, starting from the initial level (*Sura An-Nas*) until the high level (*Sura An-*

Naba). A few technological teaching aids were used in the teaching process such as Quran read pen, videos, and applications using desktop computer.

MASA (1 JAM)	CATATAN AKTIVITI (Al-Quran)	RESPON
0-5	Membaca Ruqyah	
5-10		
10-20	Membaca Doa Belajar	
20-30	Membaca & mendengar surah al-Buruj	
30-50	Menulis surah al-Buruj ayat 1-5	
50-55		
55-60	—	

Figure 3.3: Evaluation form

The duration in memorizing the Quran verses was recorded to observe their attention performance. Figure 3.4, 3.5, 3.6, and 3.7 present the comparison between average duration of focus and lost focus for every month in which each student was required to engage in the Quran memorization up to 60 minutes each session.

Figure 3.4: Average duration of focus and lost focus (Absyar)

Absyar's focus duration was not consistent. The range was between 10 to 35 minutes. Sometimes he managed to focus in a long term during memorization of the Quran verses session. In August, the average duration of focus was the highest with 34 minutes while in May it shows the lowest with 15 minutes for Absyar. The highest average duration of lost focus was in April with 18 minutes while the lowest was in June with 8 minutes.

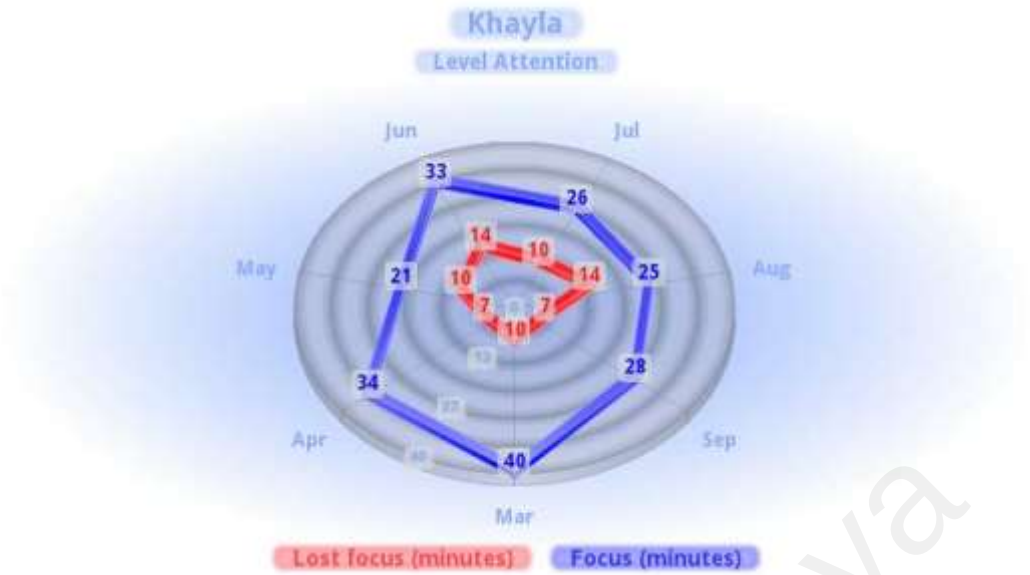


Figure 3.5: Average duration of focus and lost focus (Khayla)

Khayla showed slightly consistent focus duration during the verses of Quran memorization. The range was between 20 to 45 minutes. The polar graph demonstrates that, in March, the highest average duration of focus was 40 minutes while presenting the lowest in May with 21 minutes for Khayla. The highest in Khayla's average duration of lost focus was in June and August with 14 minutes while the lowest was presented in April and September with 7 minutes.

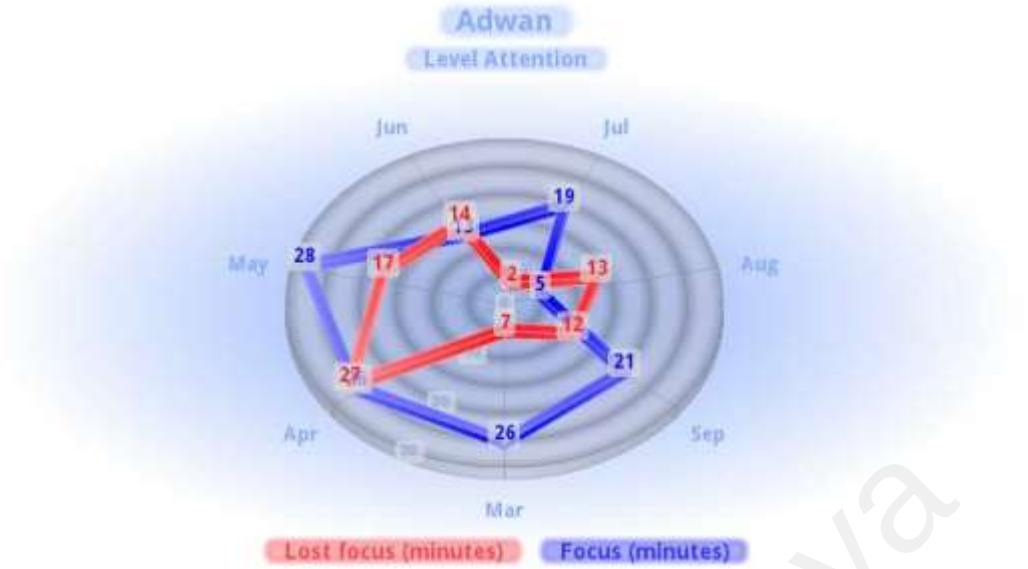


Figure 3.6: Average duration of focus and lost focus (Adwan)

Adwan's focus duration decreased starting month of June during the verses of Quran memorization. His focus duration range was between 0 to 30 minutes. The highest average duration of focus was showed in May with 28 minutes while the polar graph demonstrates the lowest in August with 5 minutes. The average duration of 27 minutes of lost focus was the highest for Adwan which was observed in April. The lowest average duration of lost focus was showed in July with only 2 minutes.

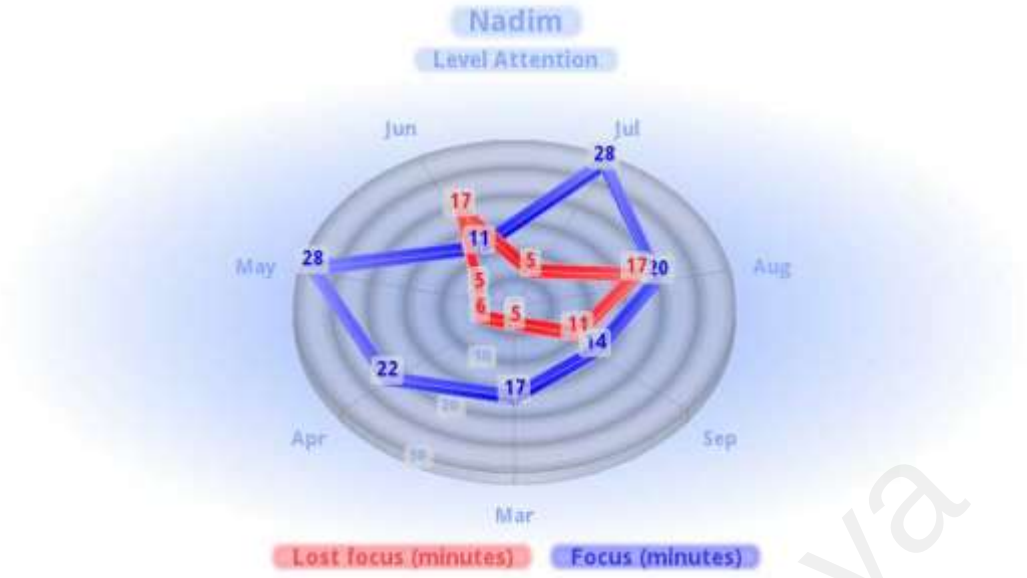


Figure 3.7: Average duration of focus and lost focus (Nadim)

The focus duration for Nadim was not consistent. Along the seven months observation, the range of his focus duration was between 10 to 28 minutes. In the early three months of memorization of the Quran verses session, Nadim managed to focus in a long term. The polar graph shows in May and July, the average duration of focus was the highest with 28 minutes for Nadim while presenting the lowest in June with 11 minutes. Average duration of lost focus was seen in June and August with 17 minutes which was the highest while the lowest was observed in March, May, and June with 5 minutes duration.

Table 3.2: Summary of students' attention performance

Subject	Level Attention			
	Focus (minutes)		Lost Focus (minutes)	
	Highest	Lowest	Highest	Lowest
1	34	15	18	8
2	28	11	17	5
3	28	5	27	2
4	40	21	14	7

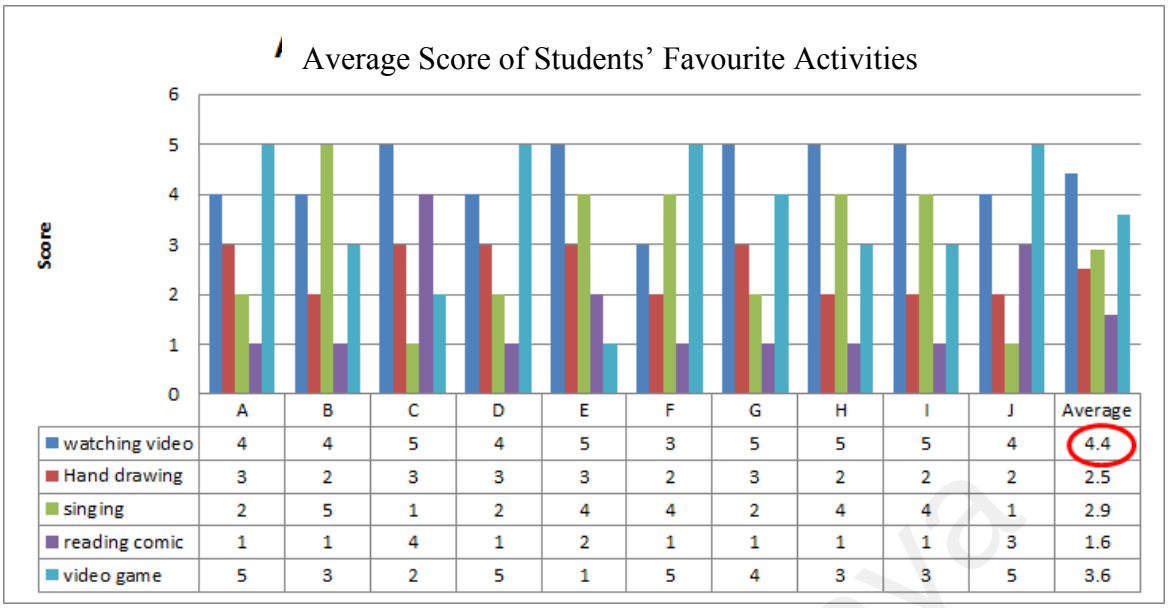
It can be deduced that all students did not achieve 45 to 60 minutes of focus duration but lasting about 10 to 30 minutes. Subject 4 was the only female student in the class and 25 years of age. From the observation, she had a good behaviour while learning. Based on the reviews on literatures combined with the interviews and observation conducted, it can be inferred that the HFA students are easily to lose focus when learning and incline to do other things when their attention is distracted.

3.3.5 Observation of Inattention Behaviour of HFAs during Memorization

As the HFAs have difficulties to sustain their attention while learning, other observation was done to view their inattention behaviour during memorization of the Quran verses. The main things to be taken into note were the students' favourite activities done when losing focus or feeling bored while memorizing the verses of Quran. The method of observation was totally the same as the observation described in the previous section, but the numbers of students to be selected as subjects were 10 students age ranging from 9 to 29 years old. Their behaviours were observed and recorded in evaluation forms as in Figure 3.3. The favourite activities were scaled based on the students' propensity towards the activity.

Figure 3.8: Few captured activities

Based on the observation, the activities or entertainments the students like were watching videos, work with hand drawings, singing, playing video games, and reading comics. Their activities are illustrated as in Figure 3.8. After memorizing the verses of Quran for certain duration, they tended to feel bored or lost focus. Thus, they asked the teachers to change to other activities but sometimes they did not ask for permission and directly kept the Quran aside to do other things. However, the teachers would restrict the time for doing other things, and then the students should continue their memorization activities. Some of the students did follow the instructions but some of them did not. The Figure 3.9 below shows the result of the observation.



	A	B	C	D	E	F	G	H	I	J	Average
watching video	4	4	5	4	5	3	5	5	5	4	4.4
Hand drawing	3	2	3	3	3	2	3	2	2	2	2.5
singing	2	5	1	2	4	4	2	4	4	1	2.9
reading comic	1	1	4	1	2	1	1	1	1	3	1.6
video game	5	3	2	5	1	5	4	3	3	5	3.6

Figure 3.9: Result of the students' favourite activities observation

According to the analyzed data displayed in Figure 3.9, the highest score of the students' favourite activities is watching video with average score 4.4, it is followed by video game with average score 3.6, singing with average score 2.9, hand drawing with average score 2.5, and the lowest score is reading comic with average score 1.6. Through this observation, it can be concluded that the HFA students tend to watch video rather than other activities when their attention is distracted.

3.3.6 Observation of Quran Memorization Techniques used among the HFAs

Other than using the *literature review technique* in identifying the most suitable technique to be adapted in the Quran memorization tool for HFA, this study also carried out the *observation technique* for students' progress monitoring that helped researcher observed the Quran memorization techniques used when the HFAs memorizing the Quran verses.

Through the *observation technique* this study conducted a project named FAKIH Pilot Project (FPP) to further observe the capability of these HFA students in using suitable skill-based technique to memorize the Quran verses. Inclusion criteria for the students to be selected as subjects in the FPP are as follows: (a) individuals with high-functioning autism; (b) not having characteristics of serious mental retardation; and (c) able to follow the FPP for 24 weeks. The five students were children and teenagers of 8 to 16 years old. Teachers those handled the HFA students in the FPP are from Islamic Education and Science background who are students from University of Malaya. The teachers were divided into five groups. Each group was managed by three teachers and had their respective tasks. The teachers had attended a theory class and eight practical classes before taking part in the FPP. In the theory class, the teachers were taught on the ways to deal with autistics. Then, in the practical classes, the teachers were given opportunities to teach the Quran to the students. During the teaching sessions, the teachers were observed and evaluated by the teachers who are experience in special education. Post-mortem was held after the each learning session.

Through the adoption of the concept of Islamic pedagogy introduced in the research theory of (A'ishah & Hardaker, 2013), the three skills which are listening, pronouncing, and memorizing had been identified to be acquired by the HFA students in this project. There are correlations among these skills in practicing the Quran memorization for them.

Listening Skill: Professionals claim that children with ASD have hypersensitivities to sound, difficulty in functioning in the presence of background noise, under-responsiveness to sound stimulation, and sensory seeking behaviours to auditory stimuli including stereotypic or repetitive behaviours (Egelhoff & Lane, 2013; Ricketts, Jones,

Happé, & Charman, 2012). Thus, the FPP tried to put an effort to deal with these weaknesses in memorization of the Quran verses.

Pronouncing Skill: It helps children with autism in learning words. According to (Ingersoll & Schreibman, 2006), the children mimic the adults in speaking. Moreover, individuals with autism are prone to sensory repetitive behaviours (Zandt, Prior, & Kyrios, 2007a). Repeated listening a word from the adults, it will encourage these individuals to pronounce the word repeatedly. Eventually, the continuous practices will enhance their memory especially through speaking or pronouncing.

Memorizing Skill: The autistics' verbal memory is unaffected although the spatial memory is affected. Moreover, they have the ability to differentiate between false memories and true memories when they are given with word stimuli (Takahashi et al., 2013). As a result of repetitive behaviours, individuals with autism able to memorize the lesson learnt.

During the FPP, the Quran memorization session was conducted once in a week. A group of three teachers were responsible in teaching a student. The first teacher was responsible to teach the student using the method one-to-one teaching; the second teacher recorded the responses given by the student during learning process using student's personal diary; the third teacher recorded videos or pictures of the student during the activity.

The memorization session involved *listening skill*, *pronouncing skill*, and *memorizing skill*. The activities can be illustrated as in the Figure 3.11, 3.12, and 3.13. In practicing the *listening skill*, the students listened to the suras those are easy to memorize such as suras in *juz `Amma*. This was followed by *pronouncing skill*. The students were required

to recite the verses those they had listened to. Through the *memorizing skill*, the students were taught on the technique to memorize the Quran verses to have better attention performance during the memorization. Each repetition of the recited verse should be marked in a form as shown in the Figure 3.10. Their listening, pronouncing, and memorizing skills those were practiced in the Quran memorization were evaluated. After finishing their memorization, the teachers would reward them with stickers featuring cartoons those were currently of interest among children, such as Ben 10, Shin-Chan, Tweety, and stickers featuring racing cars.

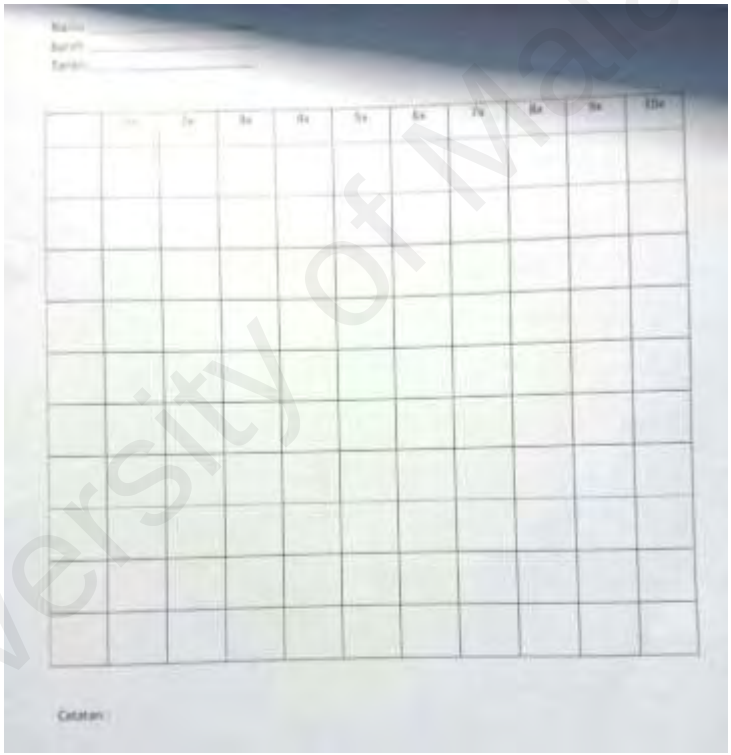


Figure 3.10: *Hafazan* form

As in Figure 3.11, 3.12, and 3.13, the teaching aids used during the FPP were Quran Read Pen (Siti Murtosiah, 2016), iQuran (Guided Ways Technologies Ltd, 2013), and videos featuring the Quran recitation with mind-stimulating pictures (MyQuranStation, 2012) with the aim to keep the students watch the videos while listening to the Quran

recitation. The table 3.3 below shows the memorization techniques which could be identified among the HFA students during the Quran memorization session in the FPP.

Table 3.3: Memorization Techniques Acquired during FPP

Skill	Memorization technique	Teaching and learning guide	Teaching Aids
Listening	1. Conventional style	1. Teacher chooses a sura learnt in previous session as a revision or a new sura to be memorized. 2. Teacher recites the selected sura with *tajwid* (correct way of reciting). 3. Student listens and follows the teacher's recitation.	-
	2. Touch and listen 3. Touch, listen, and recite	1. Teacher selects a sura. 2. Teacher asks student to use the technological teaching aid to listen to the sura selected. 3. Student follows the Quranic audio recitation.	Quran Read Pen
	4. Video visualization	1. Student watches and listens to the sura recited by the *qari* in the VCD.	Quran VCD
	5. Video /Audio recording	1. Teacher records student's behaviour/voice while he or she recites the Quran. 2. Student listens to and watches the video/voice recorded. 3. Teacher corrects the students' recitation and asks the student to repeat the recitation while it is being recorded.	iPhone, Galaxy note, Quran Read Pen
Pronouncing	1. Pronouncing as *qari*'s recitation	1. Teacher selects a sura that has been learnt in previous session as a revision or a new sura to be memorized. 2. Student pronounces like how the *qari* recites.	iPad (iQuran), Quran Read Pen
	2. Pronouncing as teacher's recitation	1. Teacher recites the sura first in slow pace while the student listens to the recitation. 2. Student pronounces like teacher's recitation and if there	-

		are mistakes, the teacher corrects it.	
	3. Video visualization	Student pronounces the Hijaiyyah letters or pronounces the Quran recitation as Quranic audio recitation.	Islamic cartoon animation VCD, Quran VCD
	4. Pronouncing word by word	Teacher recites a sura word by word and is followed by the student.	-
Memorizing	1. Teacher reciting the first word in each verse	1. Teacher asks the student to recite the sura that has been memorized. 2. Teacher recites the first few words of the verse if the student forgets the verse. 3. Student continues reciting the verse right after the teacher's recitation.	-
	2. Reciting together with teacher	Teacher asks student to recite the sura together with the teacher.	-
	3. Student categorizing verses or surah	Teacher asks the student to list down suras according to certain categories. For example: suras starting with *Alif Lam Mim*.	-
	4. Student recalling verse number	1. Teacher recites a verse from the sura that student familiar with. 2. Student guesses the verse number of the verse that has been recited. 3. Teacher asks student to recite any of the verse from the memorized sura and mention the verse number.	-
	5. Recitation with *tarannum* (melodious recitation)	Student recites the sura melodiously as *qari*'s recitation.	Quran Read Pen
	6. Memorizing by listening	1. Teacher repeatedly recites the sura to be memorized by	Quran Read Pen

		student. 2. Teacher asks the student to follow the recitation after listening to the Quranic audio recitation repeatedly.	

Figure 3.11: A student used the Quran Read Pen

Figure 3.12: A student used the iQuran in an iPad

Figure 3.13: A student watched a video while listening to the Quran recitation

3.4 Preliminary Study Outcome

During the preliminary study, the previous researches were reviewed to understand about the HFAs' attention performance, the Quran memorization techniques, approaches and frameworks of neurofeedback training, as well as the measurement tool. Besides that, interview was conducted with special education teachers and parents to get their views on students' interest in leisure-time activities especially when the attention was distracted during learning. Furthermore, observing the students during learning session was done for further investigation about their attention performance, interest in leisure-time activities, and technique used in memorizing the Quran verses.

The data obtained from the preliminary study were analyzed to get the final decision about the approaches of neurofeedback training (adaptation of the visual feedback, audio feedback, verbal response, and rewards) and components of the system framework. All the elements stated above were considered in developing the QMT.

3.4.1 Approaches Used in Neurofeedback Training

The reviews in chapter 2 bring up a question of what are the appropriate approaches to be carried out in a study of NFT for people with HFA. Most of the previous researches

had opted for visual or audio, or both feedbacks together with rewards system in implementing NFT. As previous studies had proved that most autistics have no difficulties when task given involve visual orienting, it can be inferred that main approach to be used in studies of NFT is visual feedback. However, the adoption of auditory feedback in neurofeedback system is also popular as it is certainly meaningful element to assist sustaining attention performance.

The reviews also illustrated that there had also been research that employs additional approaches such as the motor or verbal response or both in a NFT. A notable aspect to be concerned when implementing these kinds of feedbacks is it requires a particular participants' involvement in a study. The researchers should first specify a convenience sample to be used. The HFA are seen the right sample to participate in this kind of intensive as most of them have a slight difficulties in motor skills (using fingers and hand coordination) and communication (using words correctly).

Other NFT approach those most of the research teams developed is rewards system. Rewards are must to encourage and motivate the autistics for completing tasks with much better. Indirectly, the rewards system may provide positive reinforcement to the autistics' attention span. Therefore, most of the researchers have incorporated in their NFT intervention the games concept. The games concept is chosen as it is constant and immediate in providing rewards for every achievement those participants gain.

In this research project, the most preferred approaches to be adopted in the NFT intervention as a bio-hybrid system were **visual feedback**, **audio feedback**, **verbal response**, and **rewards (acted as motivation)**. Although the HFAs have slight difficulties in motor skills, the use of computer mouse was expected giving harder situation for them because some of them have difficulty to differentiate between a left

and right mouse click while at the same time they are required to give attention to the activity on the screen (AbilityNet, 2010). So that, this research would not focus to adopt the motor response approach.

3.4.2 Components of the System Framework

As previous section discussed the preferred approaches to be adopted in the NFT intervention as a bio-hybrid system, this section determines the components of the QMT system framework based on the highlighted approaches (visual feedback, audio feedback, verbal response, and rewards). According to the reviewed of existing frameworks in chapter 2, the features and methods proposed by the different researchers initiated an idea about how this research ensures the system works in increasing attention performance among autistics especially the people with high-functioning autism. In order to identify the HFAs' current attention state when memorizing the Quran verses, they need to view the screen with the integration of Quran texts and recitation (Quranic audio). Other than listening to the Quranic audio, the HFAs were also required to imitate the recitation; this is how the approach of **verbal response** could be adapted in the proposed system. The memorization session would last as their attention state was in good level. However, individual with autism is easily distracted by the environment especially the things they are obsessed. This situation may interfere with their learning process. Thus, with the learning emotions adapted in the system, the emotion of the HFAs was handled and their learning session goes well. As assimilating the learning emotions, incorporating the videos in the proposed system may change the HFAs' inattention state into the concentrate mode (Kuo & Wang, 2013); this is how the approach of **visual** and **audio feedback** could be adapted in the proposed system. As mentioned in the chapter 2, watching videos is one of the autistics' favourite activities (Brok & Barakova, 2010). Thus, it appears as a motivation for them during learning

(Szegletes & Forstner, 2013). The motivation given to the learners was how the method of self-rewarding could be adapted in the proposed system as it the purpose of the rewards system; this is how the approach of **rewards** could be adapted in the proposed system. However, the type of videos (stimuli) presented may affects the ability to sustain attention (Parasuraman, 1979). Therefore, the selection of the video type is important whereby the ability of selective attention encourages the HFA to give attention to a particular video (familiar stimulus those have been stored in their working memory). In an effort to bring back the HFAs to the concentrate mode during learning, the video presented would lead to the brainwave adjustment through the elevation of the HFAs' attention performance. Thus, the selective attention, sustain attention, and memorization skill as well as the brainwave normalization and adjustment also needed to be emphasized in designing the QMT system framework.

In summary, this study adapted the combination of components from different frameworks as a design of NFT system. The explanation was in chapter 2. Besides that, other component also was added to ensure the system behaves as a memorization tool. The assimilation of the learning emotions, self-rewarding, three entities (selective attention, sustain attention, memorization skill), process of (normalization and transformation), brainwave data, receive brainwave, and memorization session components were expected meet the necessities in developing the QMT which fit the needs of the HFAs in memorizing the verses of Quran for a longer span.

3.4.3 Students' Interest in Leisure-time Activities (Visual, Audio Feedback and Reward)

Based on the interview with the care givers of the HFAs combined with the observation conducted concerning their attention performance and behaviour during memorization

of Quran verses, the understanding of what students' interest in leisure-time activities was achieved.

The findings from the interview could be summarized that students with high-functioning autism are easily to lose focus when learning. All the interviewees agreed that when the HFAs' attention is distracted, they tend to do other things they like. Mr. Haris claimed that the HFA students have short attention duration, therefore the teachers need to play their role to grab the students' focus back to the learning process using any creative ways. However, according to Mrs Aziah who is also an expert in special education stated that this kind of students hard to follow all instructions from adults. It takes time to grab their attention. Facing this situation, Mrs. Khatimah took initiative to give break for a specified time to her students.

The activities those the students are interested in after going through the learning session for certain duration were also mentioned by the interviewees. Most of the interviewees said that the students like drawings activity. Besides that, other activities those the students are also interested in are like making origami, reading comics, pacing up and down, playing with toys or video games, watching animation videos, and listening to radio.

The findings from the observation conducted towards the HFA students during memorization of the Quran verses could be summarized that the focus duration of the students lasting about only 10 to 30 minutes. During the inattention in the middle of learning session, they were seen interested to watch videos, work with hand drawings, singing, playing video games, and reading comics.

As the observation done for about 28 weeks, the analysis showed that the activity the students most interested in is watching videos. Even though they tended to do other things when the attention distracted, some of them did continuing back memorize the Quran verses when the teachers asked for it but some of them did not follow the instructions.

In conclusion, the interview and the observation gave different results with the most interested activities were drawings and watch videos respectively. However, this research would only focus on providing videos in the development of the QMT as its **visual** and **audio feedback** as well as **reward (motivation).** Moreover, many researches had proven the effectiveness of video in learning to autistic students. Once the students' attention level is elevated, they would continue back to memorize the Quran verses. Perhaps, for the future research, the function of painting or drawing could be included in the QMT instead of watching videos to compare the results.

3.4.4 Aptitudes towards selection Quran Memorization Technique (Verbal Response)

In order to identify the most suitable technique in the Quran memorization for the HFAs, the literature review of the existing Quran memorization techniques and observation on the HFA students during the Quran memorization sessions had contributed to the ideas of the functions to be performed in the QMT. Based on the comparison between the existing memorization techniques, the *Al-Huffaz technique* was viewed more appropriate to be adapted in the system as it is the only technique aiming the Quran memorizer among children. The application of the tally method (refer to the Figure 2.3) will be modified to suit the HFAs.

During the memorization process in the FPP, the students were taught using skills that they proficient. The FPP found that the Quran memorization technique using the *listening*, *pronouncing*, and *memorizing* skills were suitable for the students with HFA with the use of the provided technological teaching aids and tally method. Although there were differences among the students in terms of reciting the Quran, each of them showed positive responses during the memorization process.

Table 3.4: Memorization Techniques Tendency Trend among the HFAs

	Skill													
	Listening					Pronouncing				Memorizing				
Memorization technique	Conventional style	Touch and Listen	Touch, listen and recite	Video visualization	Video/Audio Recording	Pronouncing as *qari*'s recitation	Pronouncing as teacher's recitation	Video visualization	Pronouncing word by word	Teacher reciting the first word in each verse	Reciting together with teacher	Student categorizing verses or suras	Student recalling verse number	Recitation with t*arannum* (melodious recitation)	Memorizing by listening
Probability student tends toward the technique (n/5)	4	2	3	4	2	3	3	2	3	4	1	1	2	1	1

Based on the Table 3.4, it can be deduced that when memorizing the verses of Quran, the HFA students tended to use the technique **conventional style**, **video visualization**, and **teacher reciting the first word in each verse** with the *probability student tends toward the techniques* is 4/5. The second highest *probability student tends toward the memorization techniques* is 3/5 with the techniques are **touch, listen and recite**, **pronouncing as *qari*'s recitation**, **pronouncing as teacher's recitation**, and **pronouncing word by word**. It can be simplified that the HFAs are able to memorize

the Quran verses effectively through *listening and mimic the adults' voice*. Therefore, the development of the QMT then would include the listening, and reciting time **(verbal response)** by adapting the function:

1. Listening to the continuous recitation of a sura without silent duration between two verses.
2. Fixed silent duration between two verses after the Quranic audio recitation for every verse to allow the student follows the recitation.
3. Adjustable silent duration between two verses after the Quranic audio recitation for every verse to allow the student follows the recitation.
4. Adjustable number of repetition of a recitation verse.

3.5 Summary

At the completion of the preliminary study, objective 1 of this research was achieved. The approaches of neurofeedback training used in the system framework were identified as visual and audio feedback, verbal response, and rewards. These approaches were adapted in the system framework through components of the learning emotions, self-rewarding, three entities (selective attention, sustain attention, memorization skill), process of (normalization and transformation), brainwave data, receive brainwave, and memorization session. The Table 3.5 describes the summary of the seven months fieldwork for the preliminary study.

Table 3.5: Summary of Fieldwork Record during Preliminary Study

No	Period	Venue	Objective	Remarks
1	March 2013	Akademi Fakih Intelek (Quran Learning Center for special needs)	Interview with special education teachers and parents about HFAs' behaviour during learning.	The HFAs tended to do other things they like when the attention was distracted. The most interested activities were drawings.
2	March – September 2013	Akademi Fakih Intelek (Quran Learning Center for special needs)	Observation of attention performance of HFAs during memorizing the Quran verses.	HFA students are easily to lose focus when learning and incline to do other things when their attention was distracted.
3	March – September 2013	Akademi Fakih Intelek (Quran Learning Center for special needs)	Observation of students' favourite activities done when losing focus or feeling bored while memorizing the verses of Quran.	Watching videos, work with hand drawings, singing, playing video games, and reading comics. However, the watching videos were most interested.
4	March – August 2013	Akademi Fakih Intelek (Quran Learning Center for special needs)	Observation of Quran memorization techniques used among the HFAs.	The technique used: listening, pronouncing, and memorizing skills were suitable for the students with HFA with the use of the provided technological teaching aids and tally method.

CHAPTER 4

DESIGN AND DEVELOPMENT

4.1 Introduction

This chapter presents the idea about the design and development activities to develop the Quran Memorization Tool (QMT) based on the designed system framework. The components of the system framework would be described further according to the outcome from preliminary study explained in the chapter 3. Then this chapter would study the behaviour and the functionality of the system through diagrams. The Object Oriented Analysis (OOA) would be used to analyze the functional and non-functional requirements which are illustrated as use case diagram and templates, activity diagrams, and class diagram. This chapter continues with the description of QMT design which is divided into two stages, first design (before pre-test) and second design (after pre-test).

4.2 System Framework

The proposed system framework consists of seven components, the learning emotions, self-rewarding, triple entities consist of (selective attention, sustain attention, memorization skill), process of (normalization and transformation), brainwave data, receive brainwave, and memorization session. The Figure 4.1 below illustrates the system framework for developing the QMT. The components with red dotted are the components from different frameworks introduced by other researchers with some modifications while the component without red dotted was added in this research study to ensure the QMT plays its role as a memorization tool. This section will describe further each component to understand the functionalities.

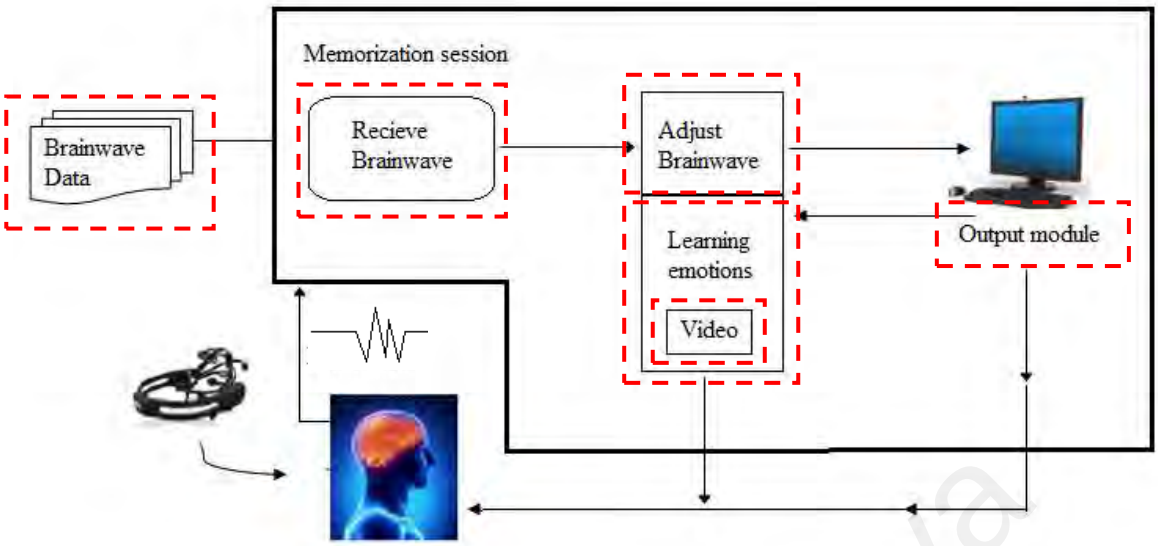


Figure 4.1: Quran Memorization Tool Framework

4.2.1 Component 1: Memorization Session

The first component of the QMT framework is memorization session. The learning process includes view the Quran sacred texts on the computer screen and listening to the recitation produced by the Quranic audio. Other than listening to the Quranic audio, the HFAs are also required to imitate the recitation either together with the played Quranic audio or right after the audio finishes its recitation. During this memorization session, the HFAs' attention may be distracted due to learning environments or feeling bored. The framework components; Receive brainwave, Adjust brainwave, Learning emotions, Video (Selective Attention, Sustain Attention, Memorization Skill), and Output module which are located in the *Memorization session* component may play their role to cater with this problem. The role of each component will be described further in the following next sections. This research study included the *Memorization session* component as memorization is crucial in learning process especially in Islamic education which it would assist an individual to embody knowledge in the Quran (Boyle, 2006; A'ishah & Hardaker, 2013). In comparison to Islamic education, the

western education highlights more on literacy learning which includes reading and writing (Bredekamp, 2014; Diane, Colker, & Heroman, 2010; W, 2015). However, the early childhood education which is mostly starts from home emphasizes on memorization before practicing to write. Thus, this study would prefer memorization as the main method of learning.

4.2.2 Component 2: Receive Brainwave

Once the brainwave reading headset is connected to the computer and the audio recitation button is played, the HFA's brain waves (attention value) are detected and recorded in the database located in the *Brainwave data* component. The brain wave (EEG signal) is then measured for the preliminary processing before the attention score is computed. This component was taken from Yunsick Sung, Kyungeun Cho, and Kyhyun Um system framework (Sung et al., 2011).

4.2.3 Component 3: Brainwave Data

The *brainwave data* component may store the entire recorded EEG signal of HFAs' brain activity. The brainwave data is important for further analysis of the HFAs' attention performance during the Quran memorization session using the QMT. This component was also taken from Yunsick Sung, Kyungeun Cho, and Kyhyun Um system framework (Sung et al., 2011).

4.2.4 Component 4: Learning Emotions

In the *learning emotions* component, two different videos were incorporated in the QMT. The method of watching videos was used for the purpose of handling the HFAs'

emotion to perform an effective learning. The watching videos were chosen as visual and audio feedback in the Quran Memorization Tool based on the outcome during the preliminary study explained in the chapter 3. The type of videos those was selected to be integrated in this system was abstract style as it is the most effective visual feedback for the autistic learners compared to other types of video (Bilikis et al., 2015). The abstract style represents animation of bright light of multiple colours. This component was taken from Yu-Chen Kuo and Tsu-Yang Wang system framework (Kuo & Wang, 2013).

4.2.5 Component 5: Adjust Brainwave (normalization and transformation)

As a part of *memorization session* component, the *adjust brainwave* component plays its important role to ensure the HFA sustain their attention for a longer span to memorize the Quran verses. For that purpose, when the computed attention scores 40 or below, the first video with abstract animation will be displayed for the purpose of elevating the attention level. After recognizing the HFA's attention greater than 40 or the attention gets back to the concentrate mode, the system will go back to the learning module (memorizing the Quran verses). However, if the attention score computed is still 40 or below for certain duration, the second video which is the same video with subtitles is displayed (Kuo & Wang, 2013). This component was taken from Yunsick Sung, Kyungeun Cho, and Kyhyun Um system framework (Sung et al., 2011).

4.2.6 Component 6: Selective Attention, Sustain Attention, Memorization Skill

This component chose videos to sustain the HFA's attention during memorization session. As the type of videos (stimuli) presented may affects the ability to sustain attention (Parasuraman, 1979), the selection of the video type is important whereby the

ability of selective attention encourages the HFA to give attention to a particular video (familiar stimulus those have been stored in their working memory). The abstract animation video in the QMT was chosen as the video representation style (multiple colours) resemble as seen in a sensory room which manage to reduce disruptive behaviour in the autistics (Fava & Strauss, 2010). This component was taken from Kavitha P Thomas, A. P. Vinod, and Cuntai Guan system framework (Thomas et al., 2013).

4.2.7 Component 7: Output Module (self-rewarding)

When the attention score detected is 40 or below during memorization session, the *output module* component will provide videos to the HFA. As video is one of the autistics' favourite activities (Brok & Barakova, 2010), it appears as a motivation for them to continue with their learning process as the main purpose of the reward system is to give motivation to do better in learning. When the HFA's attention greater than 40, the *output module* component will ensure the system goes back to the learning module (memorizing the Quran verses). This component was taken from Luca Szeglets and Bertalan Forstner system framework (Szegletes & Forstner, 2013).

The description of components adapted in the QMT can be summarized as shown in the Table 4.1.

Table 4.1: Summary of Description of QMT Framework

No.	Component of framework	Description of component
1	Memorization session	i) The HFA views the Quran sacred texts on the computer screen and listening to the recitation produced by the Quranic audio. ii) HFA is also required to imitate the recitation either

		together with the played Quranic audio or right after the audio finishes its recitation.
2	Receive brainwave	The HFA's brain wave (EEG signal) is measured for the preliminary processing before the attention score is computed.
3	Brainwave data	Store the entire recorded EEG signal of HFA's brain activity during memorization session.
4	Learning emotions	Abstract animation videos, one with and without subtitles are used for the purpose of handling the HFA's emotion to perform an effective learning during Quran memorization.
5	Adjust brainwave (normalization and transformation)	i) Ensures the HFA sustain their attention for a longer span. ii) Provides videos when the computed attention scores 40 or below. iii) Brings the HFA back to the learning module (memorizing the Quran verses) after they are in the concentrate mode (attention scores greater than 40).
6	Selective attention, Sustain attention, Memorization skill	As the type of videos (stimuli) presented may affects the ability to sustain attention, the abstract animation video (multiple colours representation style) was chosen to ensure the selective attention encourages the HFA to give attention to that particular video (familiar stimulus those have been stored in their working memory as some autistics experience learning in a sensory room surrounded with animation of multiple colours).
7	Output module (self-rewarding)	i) When the attention score detected is 40 or below, the videos will be displayed to the HFA. ii) The videos as motivation to the learners. In other words, motivation is one of the purposes of reward system. iii) When the HFA's attention greater than 40, the system goes back to the learning module (memorizing the Quran verses).

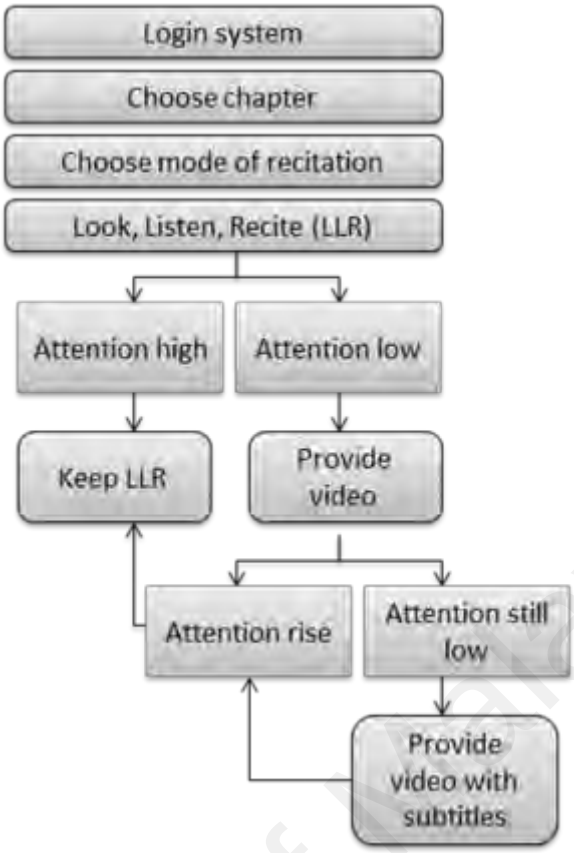


Figure 4.2: QMT Procedures Flow

In order to understand more about the QMT, the Figure 4.2 illustrates the flow of system procedures and its description as shown in the Table 4.2.

Table 4.2: Description of QMT Procedures Flow

No	Action	Description of Action
1	Login system	User will auto login to the system without username and password.
2	Choose Chapter	User will choose a sura with its verse number to be recited from the drop down menu.
3	Choose mode of recitation	User has three options: i) Listening to the continuous recitation of a sura without silent duration between two verses ii) Fixed silent duration between two verses after the Quranic audio recitation for every verse to allow the user follows the recitation iii) Adjustable silent duration between two verses after the Quranic audio recitation for every verse to allow the user follows the recitation iv) Adjustable number of repetition of a recitation verse
4	Look, Listen, Recite (LLR)	User need to look, listen, and recite when the Quranic audio recitation is played. Meanwhile, brainwave reading headset (Mindset) will start to identify the user's attention.
5	Provide video	If the user's attention fell behind the standard (40 and below), the system will start to play the abstract animation video to ensure the user's attention rise back.
6	Provide video with subtitles	If the user's attention still behind the standard, the system will start to play the same video with its subtitles to ensure the user's attention rise back.
7	Keep LLR	If the user's attention rises back or at a concentration mode, then the system will shut the video down and the user continue to look, listen, and recite when the Quranic audio recitation is played.

4.3 Analysis of Quran Memorization Tool

This section will illustrate the functional and non-functional requirements, and will present few diagrams to study the behaviour and the functionality of the system. The Object Oriented Analysis (OOA) would be used to analyze the requirements by providing the use case diagrams and templates, activity diagrams, and class diagram.

4.3.1 Use Case Diagram of QMT

Use case diagram is very important to be used throughout the entire development process for instance the project's analysis, design, testing, and implementation stages (Dedeke & Lieberman, 2006). However, this research project would only focus on the analysis part. The use case diagram was used to show the functionality of the system including the description of system actions. It consists of actors and use cases. The actors can be a person, organization, subsystem, system, or external system those playing important role of interaction in the system while the use cases are the actions. Figure 4.3 describes the use case diagram of the QMT. The actors involved in the system are teacher, student, and repository. All the actors interact with each other to perform actions to fulfill the required functionalities of the system.

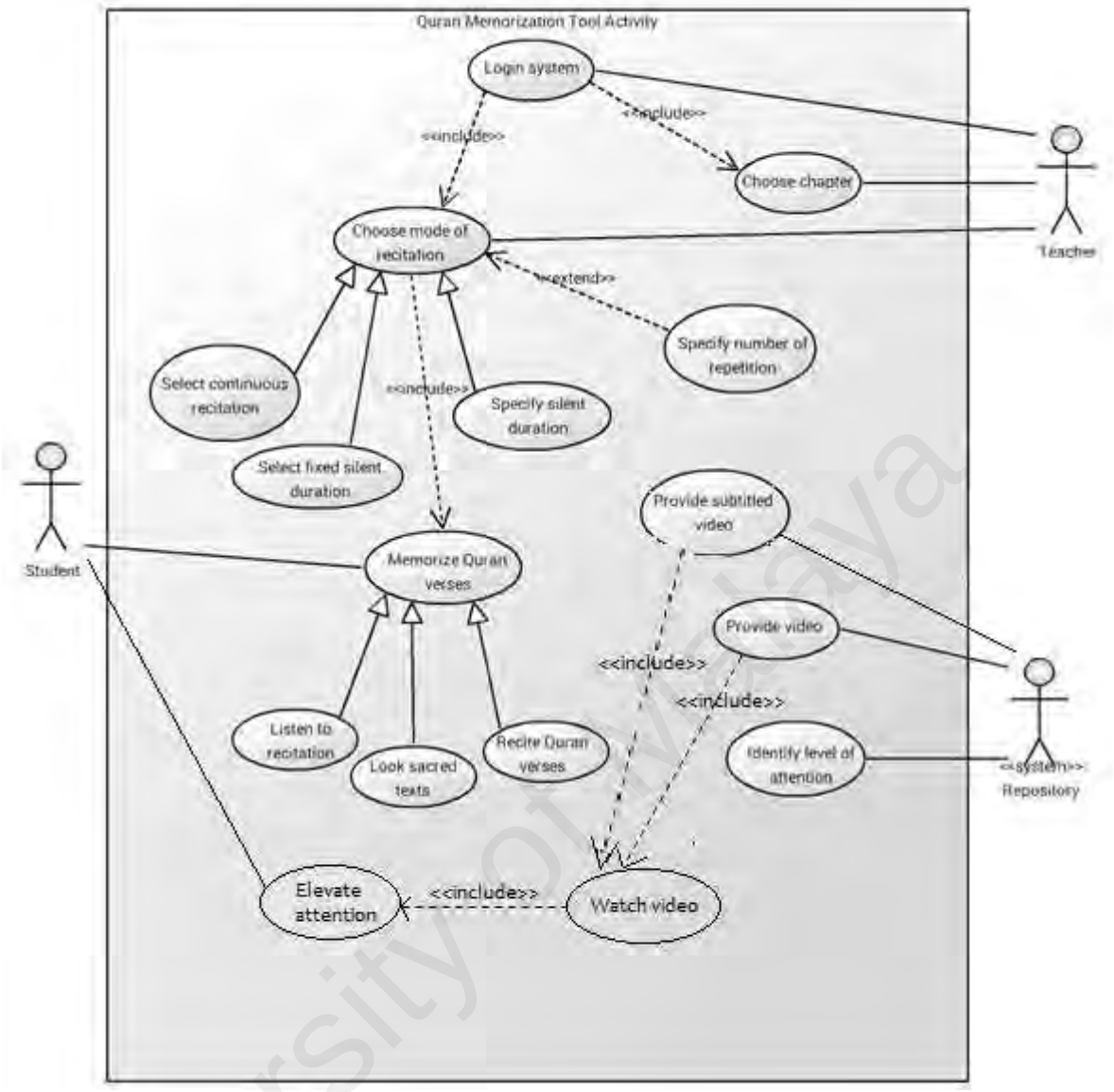


Figure 4.3: Use Case Diagram

Based on the Figure 4.3, it can be understood through the following explanation:

Teacher: Firstly, the teacher will auto login to the system without username and password to choose a sura with its verse number to be viewed by the student. Then, the teacher is required to choose the mode of Quran recitation. There are three choices which are continuous recitation of a sura without silent duration between two verses, fixed silent duration, and adjustable silent duration between two verses after the Quranic

audio recitation for every verse to allow the student follows the recitation. The teacher also has given option to adjust the number of repetition of a recitation verse.

Student: After the mode of Quran recitation has been decided by the teacher, the student need to look at the displayed Quran texts on the computer screen, listen and recite the verses of Quran once the Quranic audio recitation is played. Meanwhile, the repository (use Mindset) starts to identify the student's level attention. Besides that, when the student's level attention getting low (40 or below) the student is assisted to elevate their attention level through watching video activity which is provided by the repository.

Repository: Repository is the system itself. It plays its role by identifying and recording the student's attention scores throughout the brain activity. The repository also need to provide video when the student's attention detected is 40 or below. Finally, if the student's attention scores still at level 40 or below for certain duration, the repository needs to provide the same video with its subtitles for them to ensure their attention scores increase.

4.3.2 Use Case Templates

It is more convenient if the system behaviour descriptions embedded in the table (Coleman, 1998). Thus, use case templates were used to describe step by step the use cases in the use case diagram. The use case template consists of eight fields; use case name, description of use case which explains the goal of the use case, list of participated actors, conditions which should be true before start or during the use case to be achieved successfully, step by step explanation of interactions between actors and the system, variation field to explain if there another path to achieve the use case, non-functional

field which is optional to be filled in which it is to list the non-functional requirements, finally the issues field which is to explain if there any unresolved matters.

Table 4.3: Use Case Template for Login System Use Case

Use Case	Login system
Description	This use case is meant to require the teacher to login to the system as assisting the student to begin their memorization session
Actors	Teacher and Repository (system)
Assumptions	Teacher must auto-login to the system without entering username and password, the QMT must be displayed on the web browser.
Steps	1) Teacher starts the Visual Machine (VM). 2) Teacher starts the web server (XAMPP) in the VM. 3) Teacher connects the USB Bluetooth to the computer and switches on the Mindset. 4) Teacher puts the electrical sensors of Mindset on student's forehead and ears (scalp). 5) Teacher logs in to the system by opening the web browser. 6) System notifies the teacher that student's brainwaves (attention value) are detected by showing a small green light on the top of the system application displayed on the web page.
Variations (Optional)	If it is difficult for the teacher to login into the system, they can ask for help from the system developer (researcher of this project).
Non Functional	Performance time: The time taken to start the QMT.
Issues	Teacher needs to make sure that the electrical sensors touch the student's ears as female students wearing scarf.

Table 4.3 shows the template for *Login system use case*. The actors are teacher and repository; once the teacher login to the system by opening the web browser, the system will notify the teacher that student's brain waves (attention value) are detected by showing a small green light on the top of the system application displayed on the web page.

Table 4.4: Use Case Template for Choose Chapter Use Case

Use Case	Choose Chapter
Description	This use case is to show how teachers choose sura as well as the verse number to be memorized by students.
Actors	Teacher and Repository (system)
Assumptions	Teacher has logged in to the system and the QMT has displayed on the web page. The drop down menus of suras and verse number located at the top right corner of the QMT will be selected by teacher to start and end the chapters' recitation.
Steps	1) Teacher selects a sura from "From Sura" drop down menu with its verse number. 2) Teacher selects a sura from "To Sura" drop down menu with its verse number. 3) System displays the first sura to be recited.
Variations (Optional)	In step 1 and 2, the teacher can select any verse number, so that, the system will start reciting from the verse of sura specified in step1 and stop at the verse of chapter selected in step 2.
Non Functional	Performance time: The time taken to display the verses of a sura once the step 1 completed.
Issues	Referring the suras list in holy Quran, teacher needs to make sure that the sura selected in step 1 must be above the sura selected in step 2 in the list of drop down menu, so that, the system will be notified the sequence of suras to be recited.

Table 4.4 shows the template of *Choose chapter use case*. The actors are the teacher and system. The teacher required to specify the sura and verse number from the drop down menus "From Sura" and "To Sura". Then the system displays the first sura to be recited. The system will start and stop reciting from the verse of sura specified in those drop down menus.

Table 4.5: Use Case Template for Choose Mode of Recitation Use Case

Use Case	Choose mode of recitation
Description	This use case is meant to show how teachers choose mode of recitation from three choices with different ways of recitation before the students begin their memorization session.
Actors	Teacher
Assumptions	Teacher has logged in to the system and the QMT displayed on the web page. The sura and verse number have been selected by the teacher.
Steps	1) Teacher selects the "Continuous recitation" from the mode of recitation list. 2) Teacher types 2 to make the recitation repeat two times.
Variations (Optional)	In step 1, the teacher can select either "Continuous recitation", "Fixed silent duration", or "Specify silent duration". i) By selecting "Continuous recitation", the system will recite the verses of suras continuously; ii) By selecting "Fixed silent duration", the system will recite the verses of suras by giving space for silent time (without recitation) after an each of verse to let the student repeat the recitation. The duration of silence is the same with the duration of recitation by the Quranic audio, iii) By selecting "Specify silent duration", the number that specified by the teacher means that the system will keep silent for duration specified (seconds unit). The system will keep silent after an each of verse recitation. In step 2, the teacher can put any number of repetitions to allow the system repeats the recitation of every verse of suras.
Non Functional	Accuracy and Precision: How accurate of silence time as specified by the user.
Issues	None

Table 4.5 shows the template of *Choose mode of recitation* use case. The actor is the teacher who is going to determine the mode of recitation before the student begins their memorization session. Various modes of recitation are quite important as the teacher able to choose convenient recitation mode based on the student's learning style.

Table 4.6: Use Case Template for Memorize Quran Verses Use Case

Use Case	Memorize Quran verses
Description	This use case describes the procedures on how to begin the session to memorize the verses of Quran by students.
Actors	Student, Teacher and Repository (system)
Assumptions	Student has logged in to the system and ready with the Mindset on his/her scalp. The teacher has set the verse of sura as well as the mode of recitation and has ensured the small green light is seen on the top of the QMT which indicates the students' brainwaves (attention value) are detected. The teacher will have played the play button to begin the Quranic audio recitation which indicates the memorization session is started.
Steps	1) Student looks at the computer screen where the verses of a sura are displayed. 2) Teacher clicks the play button at the bottom of the verses of a sura displayed. 3) System starts the Quran recitation by Quranic audio according to the chosen mode of recitation. 4) Student looks at the highlighted sacred text when the Quranic audio recitation begins. 5) System starts recording the student's level of attention and continuously records along the memorization session.
Variations (Optional)	In step 4, the student begins to memorize the verses of Quran by looking to the sacred texts, listening to the Quranic audio recitation and reciting the verses together with the Quranic audio recitation or when the silence moment right after the Quranic audio recites each verse.
Non Functional	Usability: The students are able to follow the recitation easily.
Issues	None

Table 4.6 shows the template for *Memorize Quran verses* use case. The actors are student, teacher, and repository. After the teacher clicks the play button, the student begins their memorization session by looking at the Quran sacred texts displayed on the screen, listening to the Quranic audio recitation, and following the Quranic audio recitation. The system then starts recording the student's level of attention once the student starts listening to the Quranic audio recitation.

Table 4.7: Use Case Template for Provide Video Use Case

Use Case	Provide video
Description	This use case illustrates ways on how the system can provide a video while students memorize the Quran verses (Look, Listen, and Recite).
Actors	Student and Repository (system)
Assumptions	Student has logged in to the system and started memorizing by looking, listening, and reciting the verses of Quran with the Mindset on his/her scalp. The Mindset has been recording the student's attention scores. When the student's attention fell behind the standard (40 or below), the system will have started to play a video of Quran recitation with abstract animation to help the student's attention rise back.
Steps	1) Student continues the activity of Quran memorization. 2) System identifies the student's level of attention 40 or below. 3) System displays a video of Quran recitation with abstract animation. 4) Student looks at the video. 5) System continues recording the student's level of attention.
Variations (Optional)	None
Non Functional	Performance time: The time taken to display the video once the level of attention fell behind the standard.
Issues	None

Table 4.8: Use Case Template for Provide Subtitled Video Use Case

Use Case	Provide subtitled video
Description	This use case describes activity flows on how the system can provide a subtitled video right after the students watch the first video.
Actors	Student and Repository (system)
Assumptions	Student has logged in to the system and watched the first video displayed by the system after his/her attention identified has fallen behind the standard. The Mindset has continued recording the student's attention. When the student's attention identified still behind the standard (40 or below) at the end of the first video, the system will have started to play a second video which is the same video with subtitle added to help the student's attention rise back.
Steps	1) Student continues watching the first video. 2) System identifies the student's level of attention is still below than standard (40 or below) at the end of the first video. 3) System displays a second video of Quran recitation with abstract animation, the same video as before but subtitles are added. 4) Student looks at the subtitled video. 5) System continues recording the student's level of attention.
Variations (Optional)	None
Non Functional	Performance time: The time taken to display the subtitled video right after the first video ends, meanwhile the level of attention still behind the standard.
Issues	None

The table 4.7 shows the template for *Provide video* use case while the table 4.8 shows the template for *Provide subtitled video* use case. The actors of both templates are student and repository. When the system identifies the student's level of attention 40 or below during the memorization session, the system will display a video of Quran recitation with abstract animation. Meanwhile, the system continues recording the student's level of attention. Then, when the system identifies the student's level of attention is still below than standard (40 or below) at the end of the first video, the system will display a second video of Quran recitation with abstract animation, the same video as before but subtitles are added. However, when the students' attention scores

above 40, the videos automatically closed and the system brings back the student to the memorization session.

4.3.3 Activity Diagram

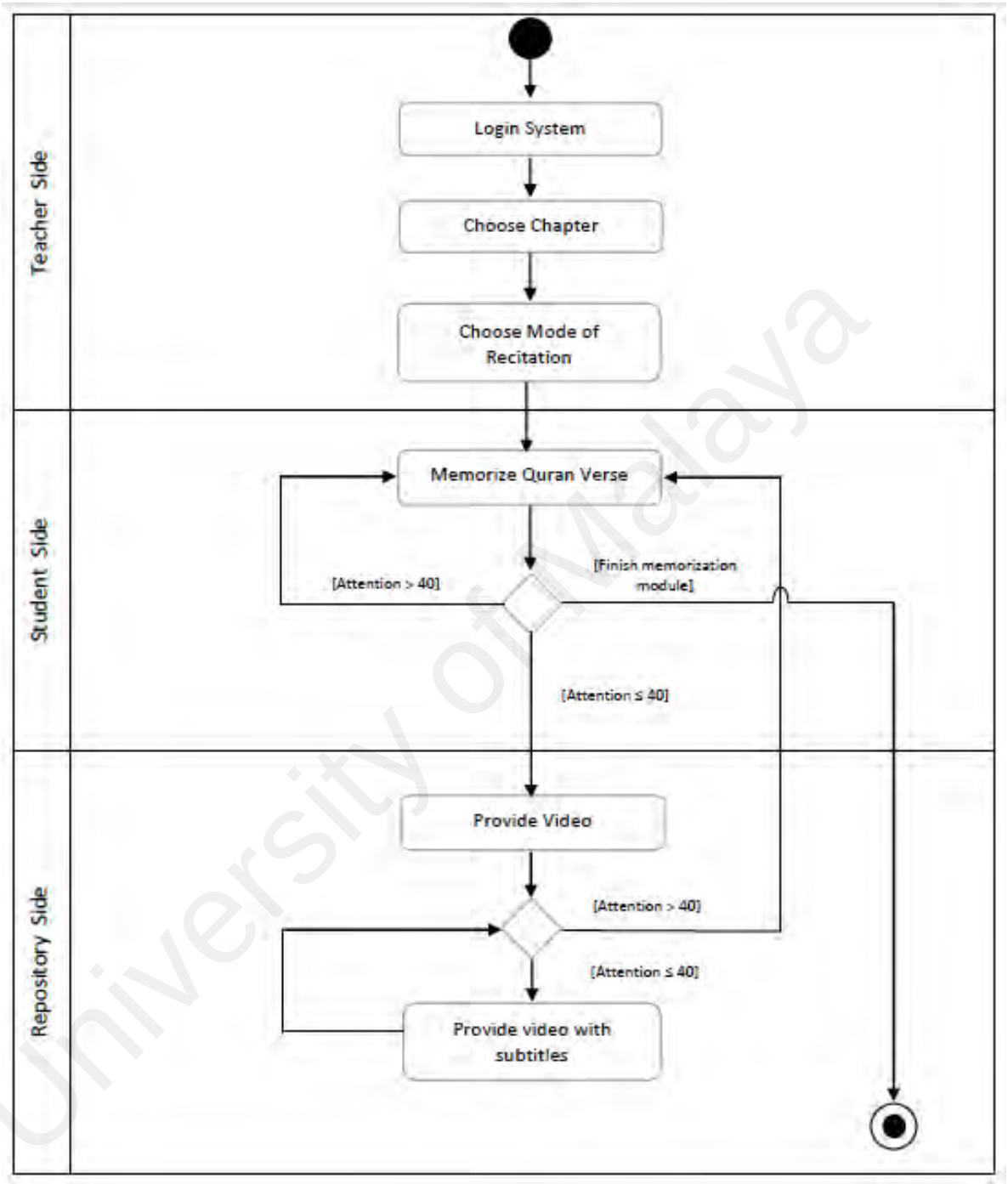


Figure 4.4: Activity Diagram

Figure 4.4 demonstrates the activity diagram for the QMT activity. It starts from the system login, choose the chapter (sura) to be memorized and the mode of recitation by the teacher. Then, the student starts to memorize the Quran verses. During the

memorization session, if the system detects the student's attention score is 40 or below, a video will be provided or else the student continues memorizing the Quran verses. As attention score is still 40 or below until the end of the first video, the other video with the same visualization and its subtitles is provided. The student is continuously provided by the second video until the attention scores above 40. However, if the attention scores above 40 after watching the first video, the system will bring the student back to the memorization session. Finally, if the student finishes the memorization module, the memorization session is ended.

4.3.4 Class Diagram

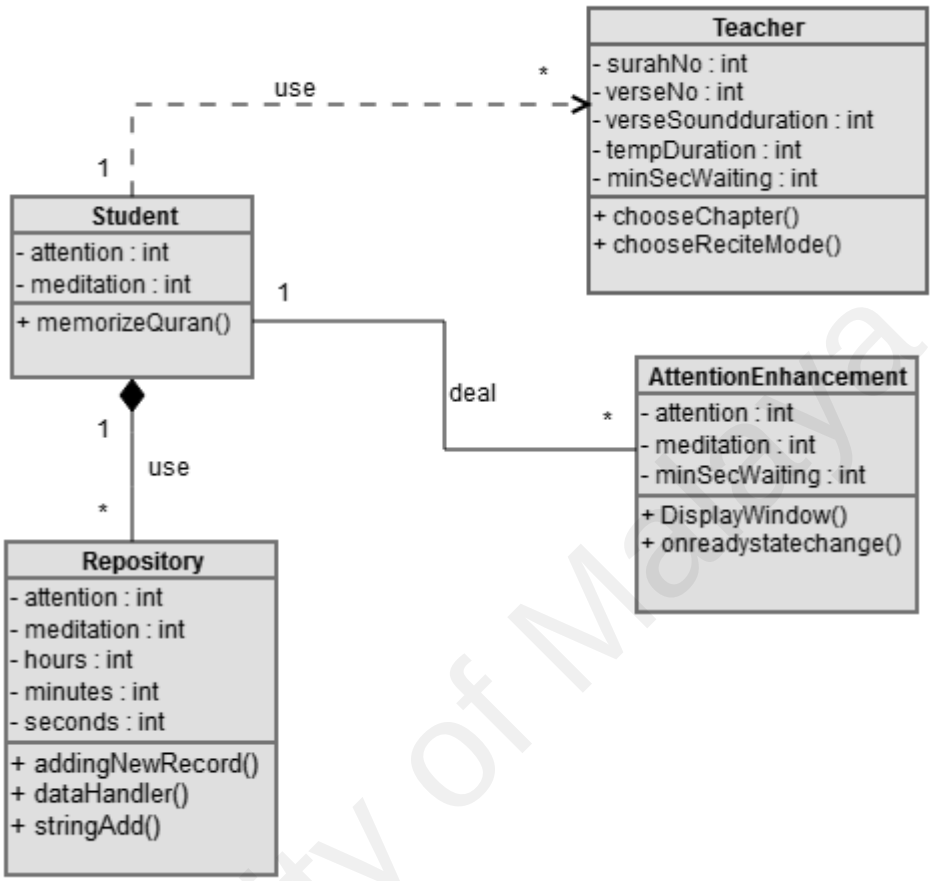


Figure 4.5: Class Diagram

The Figure 4.5 illustrates an idea about class diagram for the QMT. The relationships between the classes which could be pointed out are composition and dependency. This class diagram depicts the interrelation between teacher, student, and the system itself.

4.4 Design and Development of System

This section depicts the development of the QMT as a bio-hybrid system. It applies the neurofeedback training concept through the approaches: visual and audio feedback, verbal response, and reward. All the approaches were adapted in the QMT framework

as explained in the previous section 4.2. The QMT design and development would be divided into two stages, first design (before pre-test) and second design (after pre-test). The result of the pre-test then would be compared to the result of the post-test to determine either the enhanced Quran memorization tool could improve the HFAs' attention performance or vice versa.

4.4.1 Quran Memorization Tool Graphical User Interface

Few characteristics were considered to design the GUI of the system. The GUI should be simple, useful, helpful, and joyful for the users (teacher and students). The selection of colours of the system interface is very important as people with autism easily distracted with multicolours.

Figure 4.6: Main Interface of Quran Memorization Tool

Figure 4.6 illustrates the main interface of the QMT which has simple, coloured, and attractive view. The system interface consists of three main components; i) specification of the sura and verse number, ii) settings of the recitation mode, and iii) Quran sacred text area.

Figure 4.7: Specify the Sura and Verse Number

Figure 4.7 shows how the teacher selects a sura with its verse number from "منسورة" drop down menu to specify the starting sura to be recited by the Quranic audio and selection of a sura with its verse number from "الىسورة drop down menu to specify where the Quranic audio needs to stop its recitation. The Figure 4.8 shows the settings part for mode of Quran recitation.

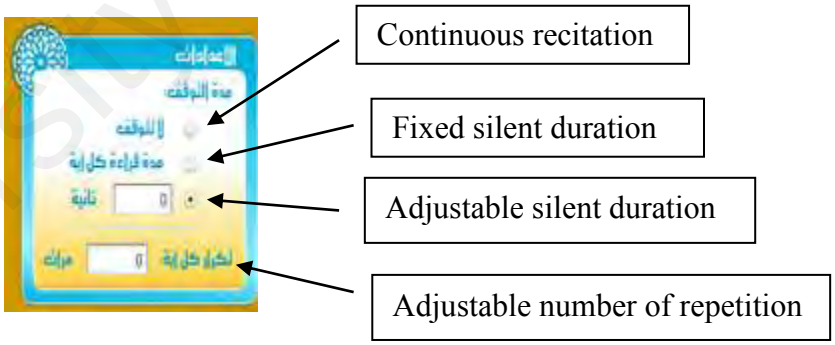


Figure 4.8: Recitation Mode Settings

Figure 4.9: Brainwaves Notification

The Figure 4.9 shows a situation when the Mindset is on the student's scalp detects the brainwaves (attention value); a small green light on the top of the system application is displayed on the web page.

The Figure 4.10 and 4.11 illustrate the videos provided by the system when the student's attention scores below the standard. Both videos reciting the *sura al-Jumu'ah* but the video as illustrated in the Figure 4.11 have its subtitle as additional visual feedback. The video included in the QMT only for the **QMT version 2**. The **QMT version 1** of the system only displays the interfaces as illustrated in the Figure 4.6 until Figure 4.9. The differences between the versions are to measure the effectiveness of the Quran Memorization Tool on the attention performance of the HFAs by using different NFT approaches.

Figure 4.10: Video with Abstract Animation

Figure 4.11: Video with Abstract Animation and Subtitles

4.5 Summary

The design and development of the Quran Memorization Tool based on the proposed system framework are to enhance the Quranic memorization progress among the HFAs. This would answer the objective 2 of this research project. However, in order to ensure either this new invention will enhance the HFAs' memorization progress or vice versa, an experiment would be conducted to obtain the HFAs' feedback on attention performance. The descriptions of the experimental evaluation (pre-test and post-test) with the HFA students on the QMT are documented in the next chapter (Chapter 5).

CHAPTER 5

EXPERIMENT AND RESULT

5.1 Introduction

This chapter presents the analysis of experimental result with the HFA students using the version 1 and 2 of Quran Memorization Tool (QMT). The objectives of the validation are described in the next section of this chapter. Besides that, the hypotheses to be tested, the information about participants, experiment settings, as well as the measurement tool used in the evaluation also provided. Furthermore, the evaluation procedures used also will be explained to obtain a good quality result in assessing the effectiveness of the QMT. Finally, the result and analysis of the validation is presented.

5.2 Validation Objectives

The invention of QMT is based on the designed system framework which adapted the neurofeedback training concept composed of approaches; visual and audio feedback, verbal response, and rewards for the purpose of enhancing the HFAs' attention span during memorization of the Quran verses. The validation objectives are as follows:

1) To measure the effectiveness of the **QMT version 1** as an intervention that enhances the attention performance of the HFAs during memorization of the Quran verses.
2) To measure the effectiveness of the **QMT version 2** as an intervention that enhances the attention performance of the HFAs during memorization of the Quran verses.

3) To investigate the HFAs' level of attention during the use of the QMT.

5.3 Students' Feedback

The HFA students' feedback was obtained through the experimental evaluation for the purpose of validating the effectiveness of the QMT in enhancing the attention performance of the HFAs, by elevating the attention span during the memorization of Quran verses. The hypothesis of the experiment is described below:

Hypothesis 1

H_1: The only approach of verbal response adapted in the QMT version 1 is **effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses.

H_0: The only approach of verbal response adapted in the QMT version 1 is **NOT effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses.

Hypothesis 2

H_1: The adaptation of the approaches; visual and audio feedback, verbal response, and rewards in the QMT version 2 is **effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses.

H_0: The adaptation of the approaches; visual and audio feedback, verbal response, and rewards in the QMT version 2 is **NOT effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses.

Hypothesis 3

H_1: The HFAs' attention level **depends** on the attractive presentation of a particular learning system.

H_0: The HFAs' attention level **DOES NOT depend** on the attractive presentation of a particular learning system.

The stated hypothesis would be tested in the evaluation part which was divided into two parts, pre-test and post-test by using the QMT version 1 and 2 respectively. The table 5.1 below shows the experimental evaluation description.

Table 5.1: Description of Experimental Evaluation on Student's Feedback

Participants	Ten HFA students were selected for both pre-test and post-test
Independent variable	Approach(s) used in the QMT (visual feedback, audio feedback, and reward)
Dependent variable	HFAs' attention state (poor attention, normal attention, or high attention)
Experimental control	i) Same HFA students participate in both pre-test and post-test ii) Verbal response approach used in both QMT version 1 and 2

5.4 Participants' Categorization

The use of the Mindset in the experimental evaluation returned the attention value. The attention values are used to record the participants' level of effort. The higher the participant's effort level, the nearer the attention score to 100 but if they make no effort at all, the attention score nearer 0 (Crowley & McDermott, 2015). The intensity of an individual's level of attention is measured using the eSense Attention meter (Neurosky, 2014). Its value ranges from 0 to 100.

Table 5.2: The Status of eSense Value

eSense value	Status Description
1-20	States of distraction, agitation, or abnormality
20-40	
40-60	"Neutral" and is similar in notion to "baseline" that are established in conventional brainwave measurement techniques
60-80	"Slight elevated" may be interpreted as levels tending to be higher than normal (levels of attention or meditation that may be higher than normal for a given person)
80-100	"Elevated", meaning they are strongly indicative of heightened levels of that eSense

Based on the eSense scale as illustrated in the Table 5.2, Katie Crowley and her colleagues identified the threshold values (attention score is 40) in order to categorize the emotional response intensity (Crowley, Sliney, Pitt, & Murphy, 2010). Referring to the percentage of time the participant's levels of meditation or attention scores below 40, the participants were grouped into three categories as described in the Table 5.3.

Table 5.3: Participant's Categorization

If (X >= 25)	Poor Attention
If (10<X < 25)	Normal Attention
If (X <=10)	High Attention

$$X = \Sigma \text{ Attention time below 40 / overall time} * 100$$

In this experimental evaluation, the value of the attention scored by the HFA students during the memorization session were calculated using the above formula, then the students were categorized according to the calculation results.

5.5 Result and Analysis

This section provides result from the HFA students' feedback through experimental evaluation (pre-test and post-test) in measuring the effectiveness of the QMT.

5.5.1 Pre-test Results and Analysis

This section demonstrates the result of the pre-test in measuring the effectiveness of the QMT version 1 for sustaining the HFAs' attention span. The Figure 5.2 until 5.11 illustrates the HFAs' attention performance during the memorization of Quran verses using the QMT.

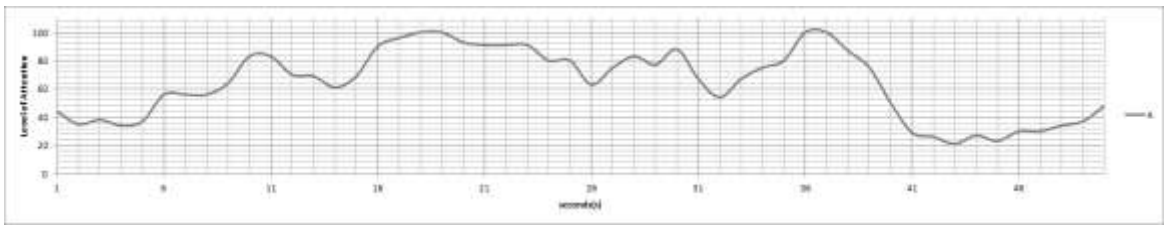


Figure 5.1: Attention Performance of Student A (pre-test)

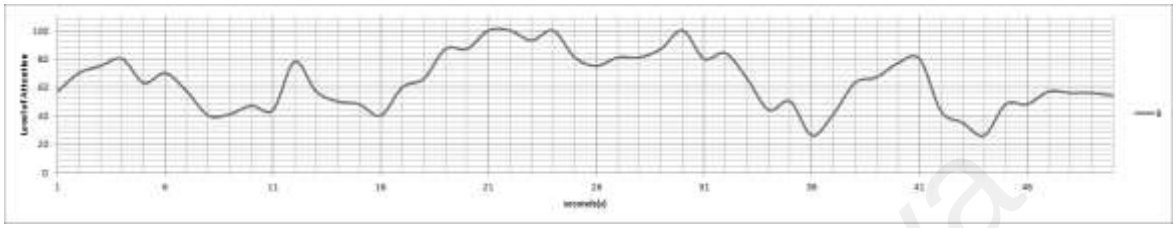


Figure 5.2: Attention Performance of Student B (pre-test)

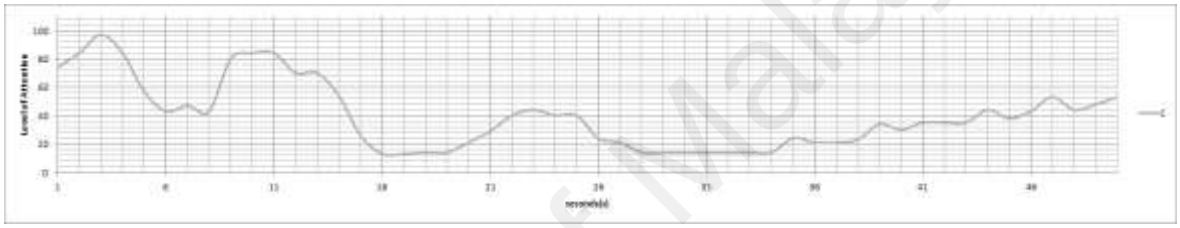


Figure 5.3: Attention Performance of Student C (pre-test)

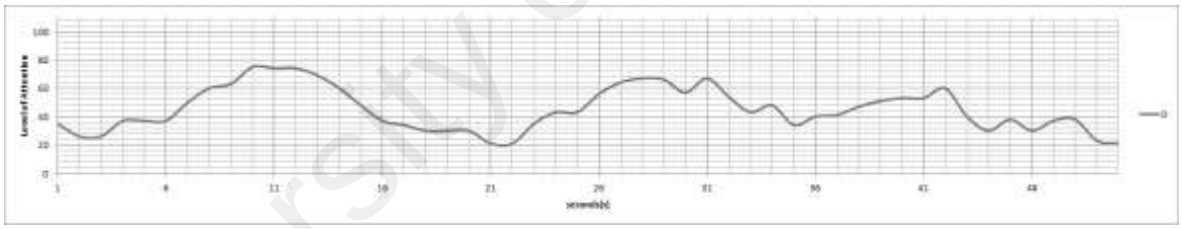


Figure 5.4: Attention Performance of Student D (pre-test)

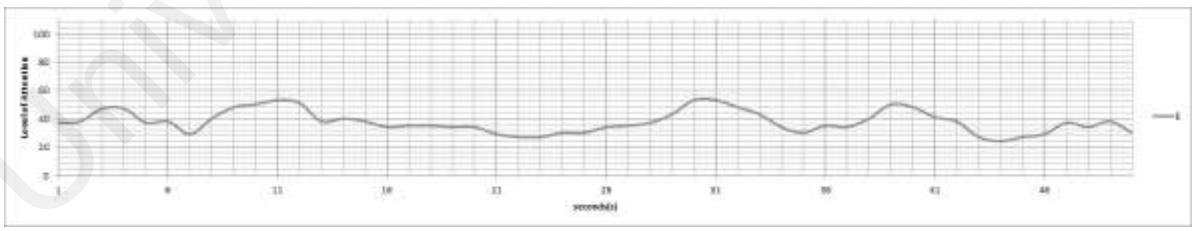


Figure 5.5: Attention Performance of Student E (pre-test)

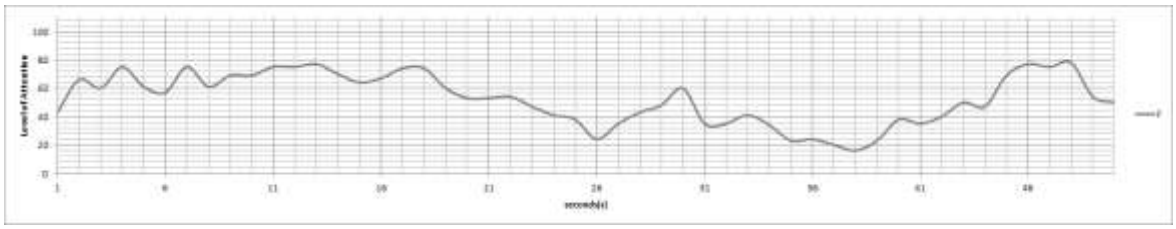


Figure 5.6: Attention Performance of Student F (pre-test)

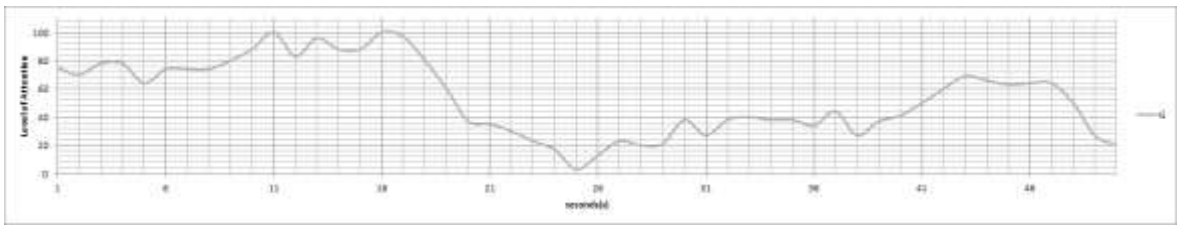


Figure 5.7: Attention Performance of Student G (pre-test)

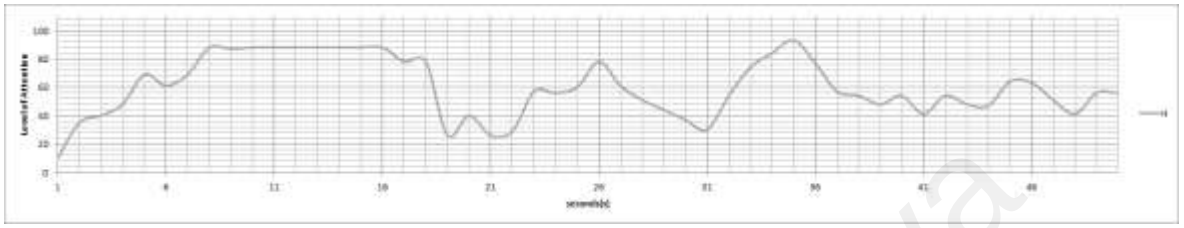


Figure 5.8: Attention Performance of Student H (pre-test)

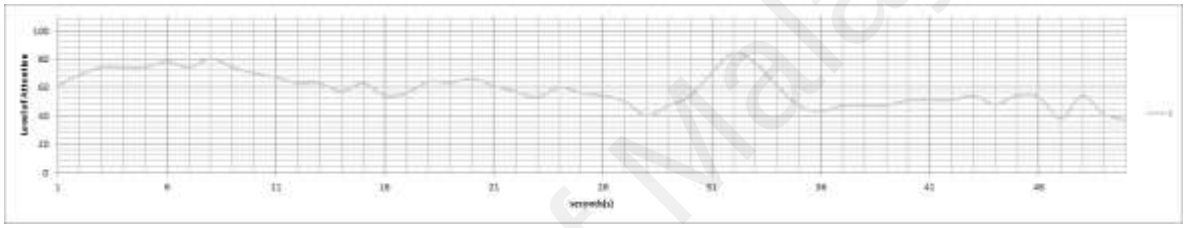


Figure 5.9: Attention Performance of Student I (pre-test)

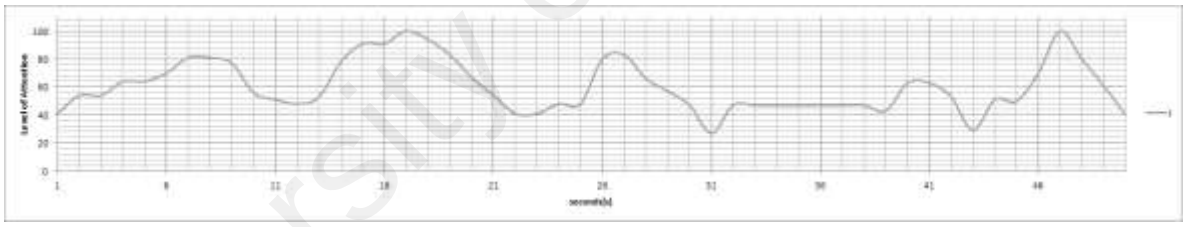


Figure 5.10: Attention Performance of Student J (pre-test)

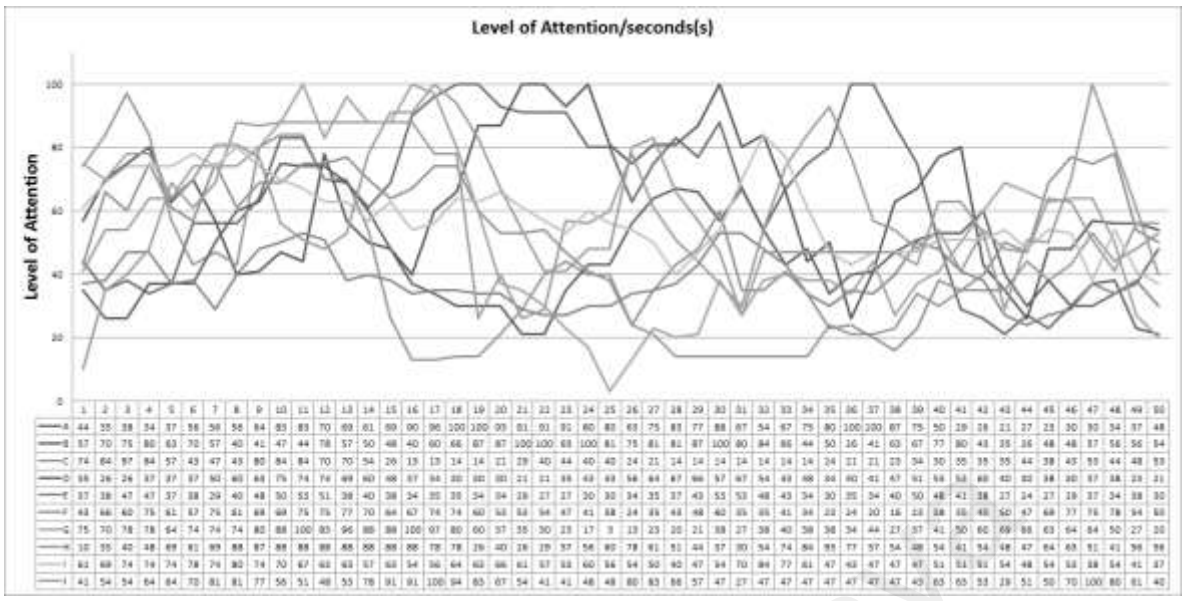


Figure 5.11: Participants' Attention Performance within 50 seconds

Analysis 1

In order to investigate the intensity of each HFA's level of attention during the pre-test, the eSense Attention meter is used. The Table 5.4 below presents each HFA student with their attention frequency for each range of eSense values.

Table 5.4: Attention Frequency based on eSense Attention Meter (Pre-test)

Attention Level		1 - 40	40 - 60	60 - 80	80 - 100
A	Frequency (%)	26	32	30	30
B		10	38	28	24
C		58	24	8	10
D		48	34	18	0
E		72	28	0	0
F		28	34	38	0
G		42	12	30	16
H		18	38	22	22
I		6	50	42	2
J		6	50	24	20
Average Frequency Rate (%)		31.4	34	24	12.4

Referring to the above Table 5.4, the HFA students' highest scored of attention level is 40-60. Their attention is at state of "Neutral" or is similar to the attention state at "baseline" in conventional EEG measurement techniques. However, there is **no significant difference** between scores 1-40 and 40-60 of the HFA students' attention level.

Analysis 2

Precisely, based on the **participant's categorization** described in the section 5.5, the HFA students' attention scores during the memorization of Quran verses using the QMT could be categorized as shown in the Table 5.5 below.

Table 5.5: Categorization of the HFAs based on the Attention (Pre-test)

Participant	**x**	**Categorization of participant**
A	26 %	Poor Attention
B	10 %	High Attention
C	58 %	Poor Attention
D	48 %	Poor Attention
E	72%	Poor Attention
F	28 %	Poor Attention
G	42 %	Poor Attention
H	18 %	Normal Attention
I	6 %	High Attention
J	6 %	High Attention

$X = \Sigma$ Attention time below 40 / overall time (50 seconds)* 100

According to the Table 5.5, it depicts that the total students those have **High Attention** during the memorization is 3 students. The total students those have **Normal Attention** is 1 student while the total for **Poor Attention** is 6 students. Based on the analysis 1 and 2, it can be deduced that the QMT version 1 needs for enhancement to ensure the HFA students can sustain their attention span for a longer term.

5.5.2 Post-test Results and Analysis

This section demonstrates the result of the post-test in measuring the effectiveness of the QMT version 2 for sustaining the HFAs' attention span. Besides that, the post-test results then would be compared to the pre-test results to observe the differences. The Figure 5.13 until 5.22 illustrates the HFAs' attention performance during the memorization of Quran verses using the QMT.

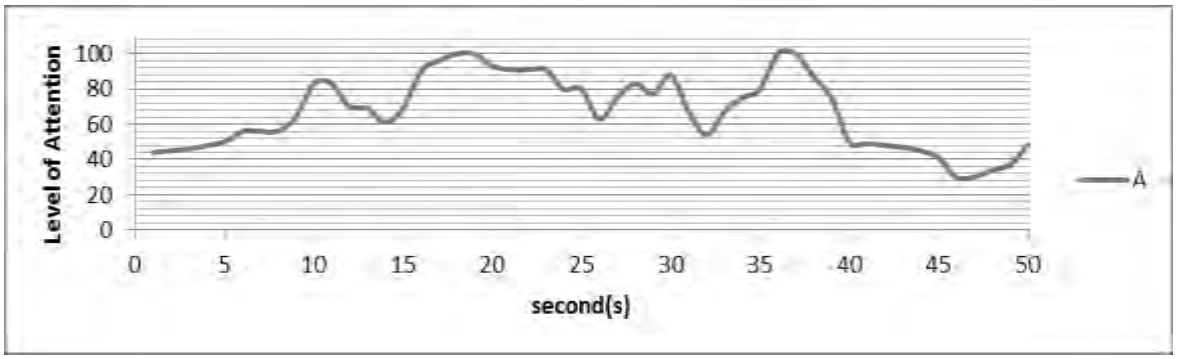


Figure 5.12: Attention Performance of Student A (post-test)

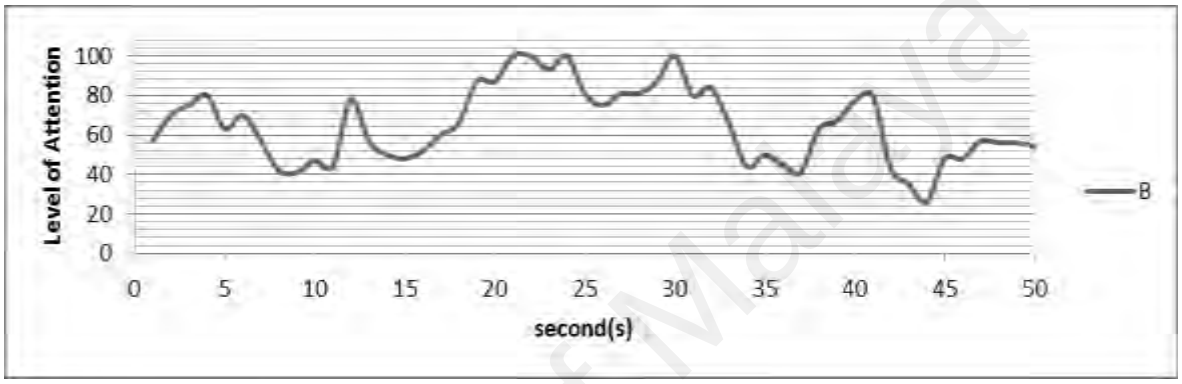


Figure 5.13: Attention Performance of Student B (post-test)

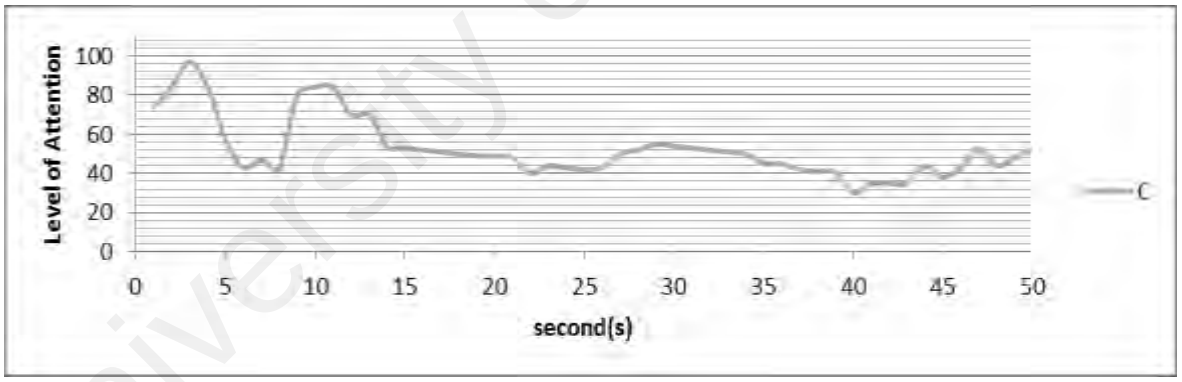


Figure 5.14: Attention Performance of Student C (post-test)

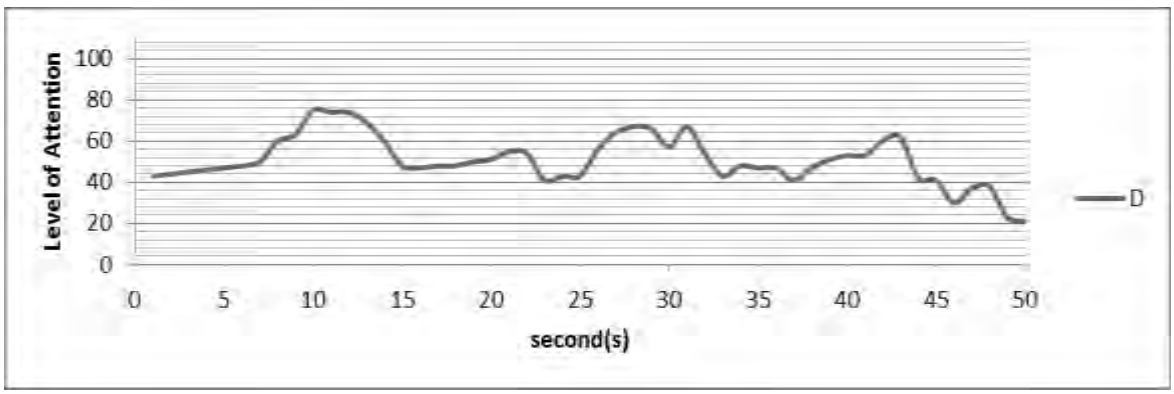


Figure 5.15: Attention Performance of Student D (post-test)

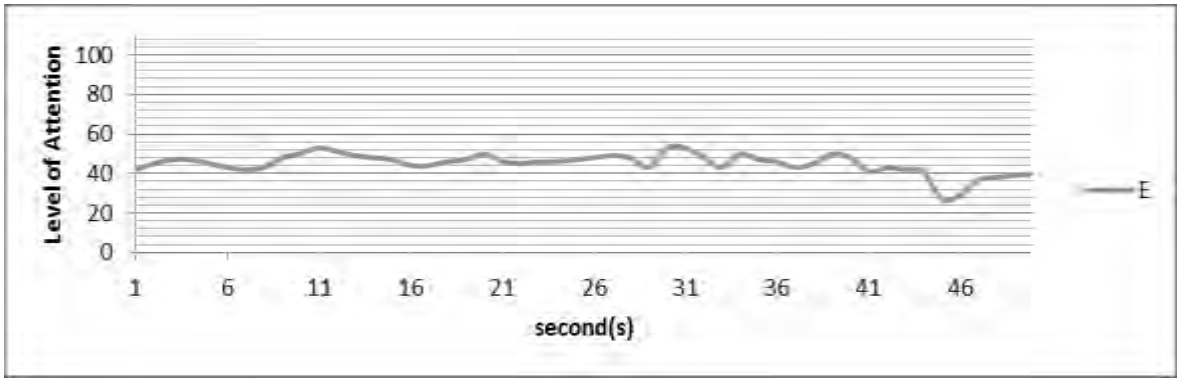


Figure 5.16: Attention Performance of Student E (post-test)

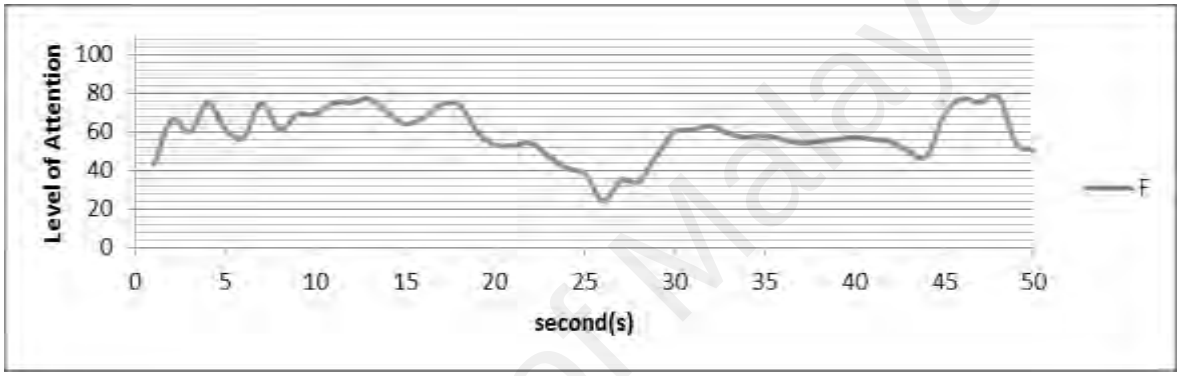


Figure 5.17: Attention Performance of Student F (post-test)

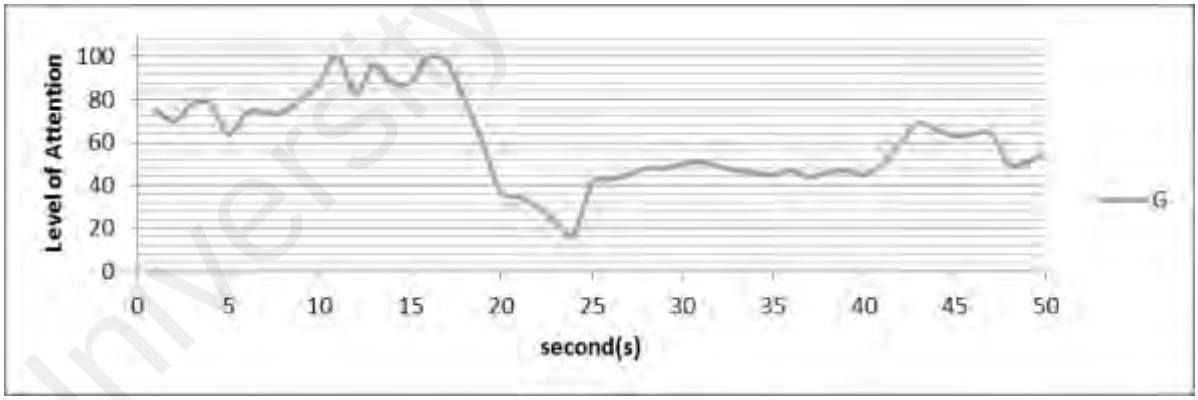


Figure 5.18: Attention Performance of Student G (post-test)

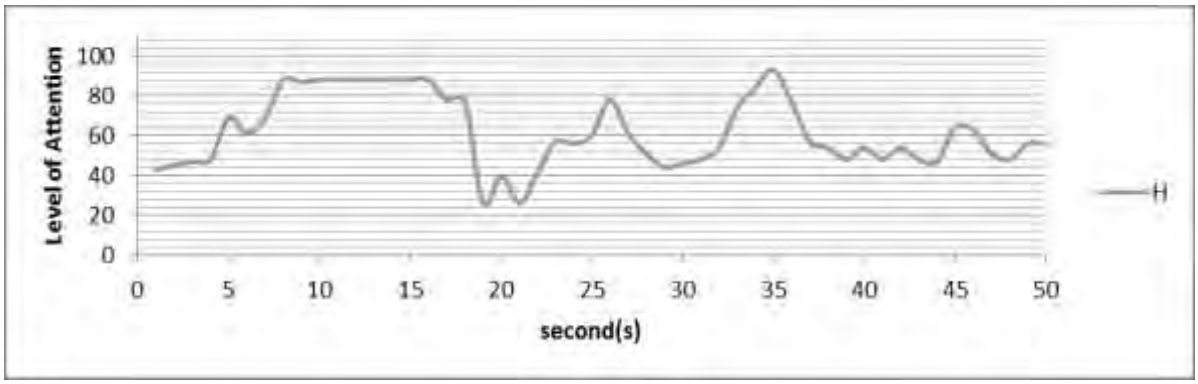


Figure 5.19: Attention Performance of Student H (post-test)

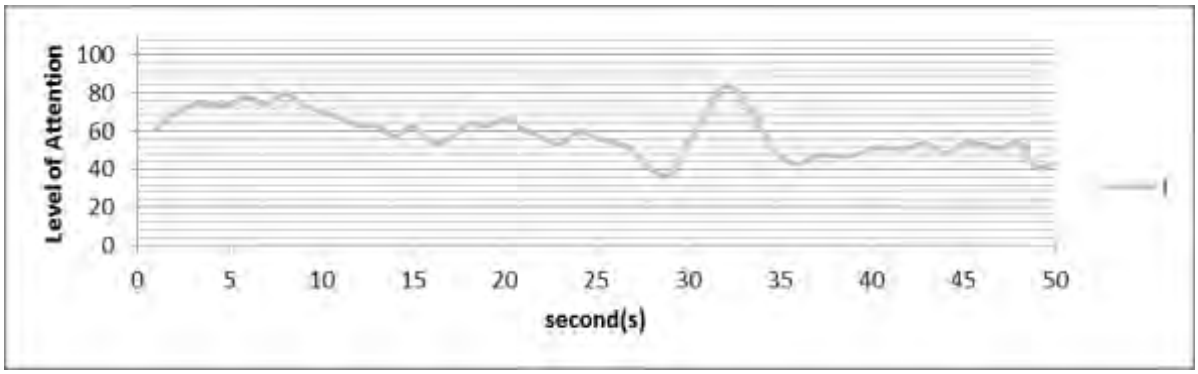


Figure 5.20: Attention Performance of Student I (post-test)

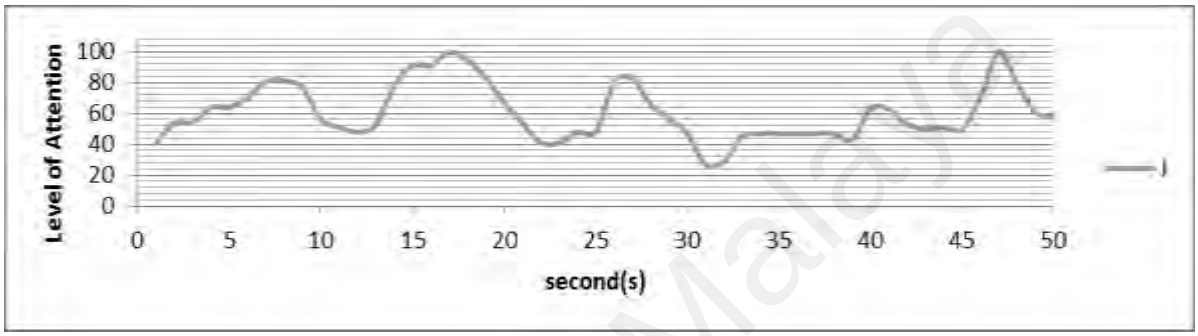


Figure 5.21: Attention Performance of Student J (post-test)

Analysis 3

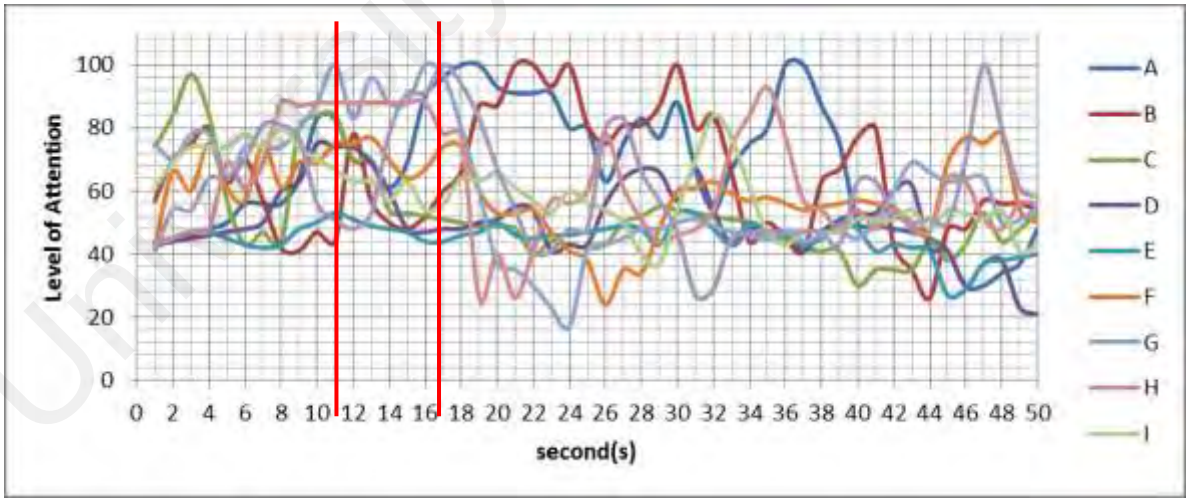


Figure 5.22: Students' Attention Performance within 50 Seconds

The Figure 5.23 shows a graph with all students' attention performance within 50 seconds during the use of QMT version 2. It indicates that almost the students' attention level getting higher at the 11th second with the average score of attention level is 66.4

(refer to the Figure 5.24). At the 11th second, the 2nd verse of *sura al-Jumu'ah* is recited by the Quranic audio. The meaning of the verse is as follows:

> *Allah has sent amongst the illiterate a messenger (Muhammad S.A.W) from among themselves, to rehearse to them His Signs, to sanctify them, and to instruct them in Scripture and Wisdom as before the Prophet Muhammad is sent, they had been in manifest error.*

It is expected that these HFA students were emotionally affected by the underlined 2nd verse as the verse meanings seem meant for them. Listening to the Quran is one of the sound therapies and it can manage physical and mental stresses (Dini Farhana & Melati, 2011; Shafiei et al., 2011). It is possible that the meaning of the underlined 2nd verse elevated their attention level to the higher score.

Besides that, at the 17th second also depicts the higher attention level with the average score of attention level is 65.5 (refer to the Figure 5.24). At the 17th second, the Quranic audio is still reciting the 2nd verse of the *sura al-Jumu'ah*. At this point, the meaning of the verse is as below (underlined text):

> *Allah has sent amongst the illiterate a messenger (Muhammad S.A.W) from among themselves, to rehearse to them His Signs, to sanctify them, and to instruct them in Scripture and Wisdom as before the Prophet Muhammad is sent, they had been in manifest error.*

The underlined meanings "His Signs" may refer to the *Allah's* oneness, power, wisdom and goodness which each of them contains signs as stated in Allah's revelations in the Quran. Referring to *sura al-Anfal*, verse number 2,

True believers are those whose hearts tremble with awe at the mention of Allah's name,

It believed that these HFA students who do not have sins and have pure heart, their emotional were again affected by the recited sentence with its meanings "His Signs". Their attention level was again elevated.

In between the 18th second to 33rd second and 39th second to 50th second, the graph in the Figure 5.23 shows most of the students' attention level getting decreased and elevated back for a few seconds. At these points, the students were likely watching the video with abstract animation provided when their level of attention scored 40 and below. After the attention elevated and scored above 40, the abstract animation video disappeared and they continued the memorization session back.

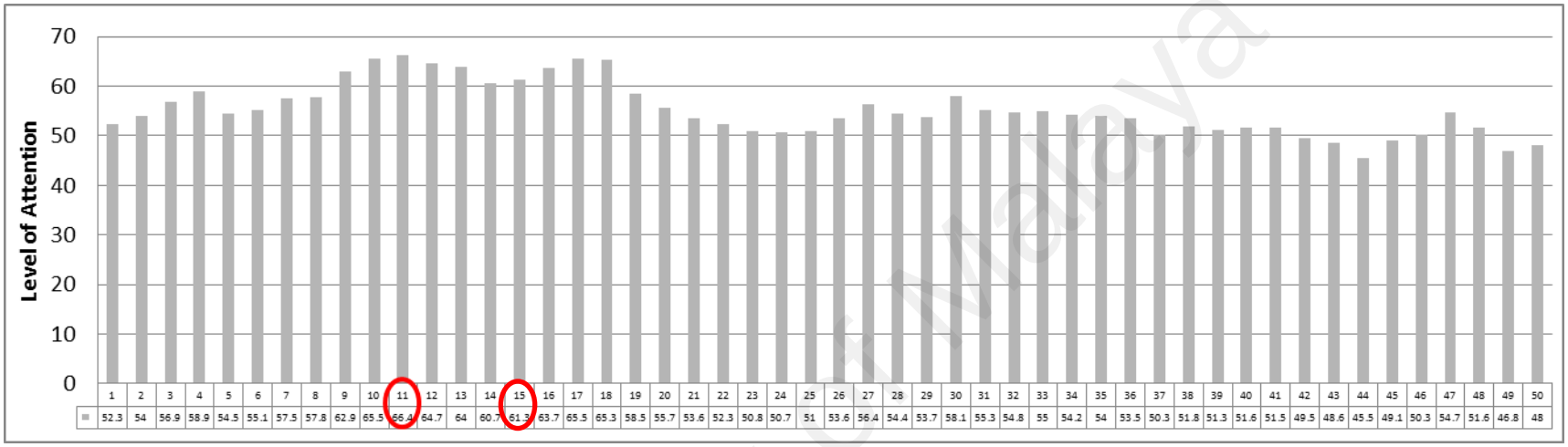


Figure 5.23: Average Score of Attention Level

Analysis 4

Table 5.6: Attention Frequency based on eSense Attention Meter (Post-test)

Attention Level		1 - 40	40 - 60	60 - 80	80 - 100
A	Frequency (%)	8	32	30	30
B		4	44	28	24
C		12	70	8	10
D		10	70	20	0
E		12	35	0	0
F		8	50	42	0
G		10	44	30	16
H		8	48	22	22
I		4	52	42	2
J		4	52	26	18
Average Frequency Rate (%)		8	49.7	24.8	12.2

Referring to the above Table 5.6, the HFA students' highest scored of attention level is 40-60. Their attention is at state of "Neutral" or is similar to the attention state at "baseline" in conventional EEG measurement techniques. Comparing the results between pre-test and post-test which both illustrated the range of HFAs' attention level is between scores 40-60, the total average frequency rate of attention for the HFA students during the **post-test** is higher than **pre-test**. Furthermore, there is **significant difference** between scores 1-40 and 40-60 of the HFA students' attention level compared to the pre-test.

Analysis 5

An extension of the analysis 4, by using the **participant's categorization** described in the section 5.5, the HFA students' attention scores during the memorization of Quran verses using the QMT could be categorized as shown in the Table 5.7 below.

Table 5.7: Categorization of the HFAs based on the Attention (Post-test)

Participant	x	Categorization of participant
A	8 %	High Attention
B	4 %	High Attention
C	12 %	Normal Attention
D	10 %	High Attention
E	12 %	Normal Attention
F	8 %	High Attention
G	10 %	High Attention
H	8 %	High Attention
I	4 %	High Attention
J	4 %	High Attention

$X = \Sigma$ Attention time below 40 / overall time (50 seconds)* 100

The Table 5.7 demonstrates that the total students those have **High Attention** during the memorization is 8 students while the total for **Normal Attention** is 2 students. There are no students categorized in **Poor Attention**. In comparison to the result in pre-test, the ratio of students those categorized in High Attention during the post-test to the pre-test is 8:3 when using the QMT version 2 which resulted in more effective in improving the HFAs' attention performance.

Analysis 6

The results obtained in this experimental evaluation were also analyzed using the Wilcoxon Signed Ranks test to show strong evidence in the **Analysis 2** and **Analysis 5**. The analyzed data is presented as follows:

Table 5.8: NPar Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Pre-test (X value)	10	28.2000	21.75520	4.00	66.00	5.5000	26.0000	46.0000
Post-test (X value)	10	7.0000	3.23179	2.00	12.00	3.7500	7.5000	9.2500

Table 5.9: Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Post-test (X value) - Pre-test (X value)	Negative Ranks	10[a]	5.50	55.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	10		

a. Post-test (X value) < Pre-test (X value)

b Post-test (X value) > Pre-test (X value)

c. Post-test (X value) = Pre-test (X value)

Table 5.10: Test Statistics

	Post test (X value)-Pre-test(X value)
Z	-2.805[b]
Asymp. Sig. (2-tailed)	.005

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Based on the analysis shown in the both Analysis 2 and Analysis 5, Post-test (X value) is less than Pre-test (X value). According to the Table 5.3 (Participant's Categorization), the smaller the value of X, the higher the level of attention. It indicates that the Post-test results are better than the Pre-test results with the higher total of students categorized by **High Attention**. It can be deduced that the QMT version 2 is effective to enhance the HFAs' attention span during the memorization of Quran verses.

5.5.3 Hypothesis 1

The hypothesis $\mathbf{H_0}$ tested if the only approach of verbal response adapted in the QMT version 1 is effective in sustaining the HFAs' attention for a longer span during the memorization of Quran verses or vice versa. The results of the experimental evaluation have shown that with the only approach of verbal response adapted in the QMT version 1 is **not effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses.

5.5.4 Hypothesis 2

The Hypothesis **H_1** tested if the adaptation of the approaches; visual and audio feedback, verbal response, and rewards in the QMT version 2 is effective in sustaining the HFAs' attention for a longer span during the memorization of Quran verses as compared to the QMT version 1. The results of the experimental evaluation have shown that the adaptation of the approaches; visual and audio feedback, verbal response, and rewards in the QMT version 2 is **effective** in sustaining the HFAs' attention for a longer span during the memorization of Quran verses as compared to the QMT version 1.

5.5.5 Hypothesis 3

The Hypothesis **H_1** tested if the HFAs' attention level depends on the attractive presentation of a particular learning system or vice versa. The results of the experimental evaluation (in Analysis 1 and Analysis 4) have shown that the HFAs' attention level depends on the attractive presentation of a particular learning system.

5.6 Summary

The analysis of the results depicted that the HFA students' attention level is between the ranges 40-60 which is at state of "Neutral" or is similar to the attention state at "baseline" in conventional EEG measurement techniques. However, the attention performance was enhanced when they were rewarded to watch a video with abstract animation in the middle of distracted concentration mode (attention level scores 40 or below) during the use of the QMT. Furthermore, the hypothesis 1 (H_0), hypothesis 2 (H_1), and hypothesis 3 (H_1) were supported by the results. Hence, the invention of the QMT based on the attention of the HFAs is effective with the adaptation of approaches

visual and audio feedback, verbal response, and rewards for the purpose of enhancing the HFAs' attention performance during memorization of the Quran verses.

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Introduction

This chapter gives an overview of the research project. The first section elaborates on the summary of why and how the research was conducted as according to the research objectives. The second section focuses on discussion. The third section answers the research questions. The fourth section discusses on the limitation of the research. Last but not least, the fifth section provides suggestion for future enhancement.

6.2 Research objectives

Students with high-functioning autism have difficulties in attention especially during the memorization of Quran verses. They fail to sustain the attention in a longer term. The use of technological teaching aids is a good idea to ensure their learning sessions are fun. However, it is necessary to develop apps or tools as the technological teaching aids to suit the use for them. This is due to most of existing applications developed are suitable for typical individuals. This includes the suitability of memorization techniques to be practiced among them, such as; using tally method manually is difficult for some students without any devices used to assist them counting the recited verses automatically. Getting exposure to the knowledge contained in the Quran is important for HFA students in shaping their social skill and further in instilling Muslim characteristics in themselves. As they have the capability to remember things quickly, it is good to give chances for them to explore more the Quran.

In order to assist them memorizing the Quran verses for a longer span which is to enhance the attention performance, the existing Quran application provided in the market should be improved so that it gives an impressive view for the HFA students. The elements those should be considered in improving the existing Quran application as a device to assist in memorizing the Quran verses for HFA students are the visual feedback, audio feedback, provides chances to the students to give verbal response, and motivating them by giving rewards. Neurofeedback training has successfully trained the attention performance and it shows good research support for its effectiveness in treating autism (Hammond, 2008), this research project adopted the concept of neurofeedback training (NFT) as a method in implementing the Evolving Living Technology (EVLIT).

Therefore, these had brought to the achievements of the three research objectives of this research project:

1. To identify HFAs' attention performance, favourite activities done when the HFAs losing focus and the most suitable technique in the Quran memorization for HFAs.

The first research objective was divided into three parts. The **first part** is to identify the HFAs' attention performance during the memorization of Quran verses. This was achieved through the literature review explained in the chapter 2, observation and interview conducted during the preliminary study explained in the chapter 3. It can be inferred that the HFA students are easily to lose focus when learning and incline to do other things when their attention was distracted.

The **second part** is to identify favourite activities done when the HFAs losing focus. This was achieved through the interview and observation during the preliminary study which explained in the chapter 3 with the findings was shown that the most interested

activities are drawings and watch videos. However, this research only focuses on providing videos in the development of the QMT as its visual and audio feedback as well as reward (motivation).

The **third part** is to identify the most suitable technique in the Quran memorization for HFAs. This was achieved through the literature review and observation during the preliminary study presented in the chapter 3. The further review on the literatures was explained in the chapter 2. The findings have shown that the development of the QMT should have the functionalities of listening and reciting time (verbal response). This has been described in the chapter 3.

2. To design a new tool that enhances the Quran memorization attention among the HFAs using neurofeedback training.

The second research objective was achieved by designing and developing the QMT. The design and development of the QMT version 1 was enhanced by producing the QMT version 2. This has been described further in the chapter 4. This research objective also was achieved through the result and analysis in chapter 5 with the identification of QMT is effective if it adapted the neurofeedback training approaches; visual and audio feedback, verbal response, and rewards.

3. To measure the effectiveness of the Quran Memorization Tool on the attention performance of HFAs using the Evolving Living Technology (EVLIT).

The third research objective was achieved through students' feedback using experimental evaluation during the pre-test and post-test. The hypothesis 1 (H_0), hypothesis 2 (H_1), and hypothesis 3 (H_1) were supported by the results obtained and analysis done. These have been elaborated in the Chapter 5.

6.3 Discussion

In an effort to sustain the HFA students' attention during memorizing the Quran verses is very challenging. Some of them will unexpectedly switch to other activities, while others are still memorizing the Quran verses even though unfocused as they are seen looking around or tapping on the desk (anxious to do other things as they feel that the teacher will scold them). These gave the teachers a perception that either the students are still learning or they are distracted. Hence, in order to invent a new tool that will be effective in enhancing their attention during the memorization of Quran verses, several aspects were considered including the system design and the learning process.

In the aspect of the system design, few literature reviews were done. As one of the most recent technologies used in a system development is EVLIT, the development of the QMT considered the abilities of sensors and actuation which introduced in the EVLIT. Those abilities were integrated in the QMT by adapting the common approaches in neurofeedback training on the proposed QMT framework. Consider the suitability with the HFA users, the approaches adapted were visual feedback, audio feedback, verbal response, and rewards. The QMT framework was built from the combination of several components. It includes learning emotions, self-rewarding, three entities (selective attention, sustain attention, memorization skill), process of (normalization and transformation), brainwave data, receive brainwave, and memorization session.

In the aspect of learning process, those components of the system framework were functioned based on the decided approaches. Other than listening to the Quranic audio, the HFA was also required to imitate the recitation based on the selected mode of recitation by teachers. The choices of recitation mode were based on the Quran memorization techniques those fit the HFAs' needs, these were how the approach of

verbal response was adapted in the QMT. The memorization session lasted as their attention state is in good level.

However, individual with autism was easily distracted by the environment especially the things they were obsessed. This situation had interfered with their learning process. Thus, with the learning emotions adapted in the system, the emotion of the HFA was handled and their learning session went well. As assimilating the learning emotions, incorporating the videos in the QMT had changed the HFA's inattention state into the concentrate mode, these were how the approach of **visual** and **audio feedback** were adapted in the QMT.

Watching videos is one of the autistics' favourite activities which were identified during the preliminary study. Thus, it appeared as a motivation for them during learning. The motivation given to the learners was how the method of self-rewarding was adapted in the QMT as it the purpose of the rewards system, this was how the approach of **rewards** was adapted in the QMT.

However, the type of videos (stimuli) presented may affects the ability to sustain attention. Therefore, the selection of the video with abstract animation was important whereby the ability of selective attention encourages the HFA to give attention to a particular video (familiar stimulus those had been stored in their working memory). Some of the autistics experience learning in sensory room with the multicolours abstract animation, thus they did remember the abstract animation.

In an effort to bring back the HFA to the concentrate mode during learning, the video was used so that the QMT able to do brainwave adjustment through the elevation of the HFA's attention performance. Thus, the selective attention, sustain attention, and

memorization skill as well as the brainwave normalization and adjustment also needed to be emphasized in designing the QMT.

During the evaluation, few challenges had been gone through to ensure the evaluation session run well. Sometimes the system got problems to run the server, the brainwave reading headset got problems to detect the participant's brainwave which requires repeating the test with that participant. Besides that, other challenges those must be faced were with the students' behaviour during the evaluation. Few of them got tantrum before the test, eating while the test running, and got bored waiting for the system to ready. However, they managed to control and handle their emotion when the test was starting.

Based on the analysis of the HFAs' attention performance during pre-test and post-test, it was believed that the attention performance was enhanced when they were rewarded to watch a video with abstract animation in the middle of distracted concentration mode (attention level scores 40 or below) during the use of the QMT.

It is also can be deduced that the invention of the QMT based on the attention of the HFAs was effective with the adaptation of approaches visual and audio feedback, verbal response, and rewards for the purpose of enhancing the HFAs' attention performance during memorization of the Quran verses.

6.4 Research questions

The research questions in the chapter 1 are answered here. The questions are as follows:

i) What is the relation between EVLIT and neurofeedback training?

This research study uses the EVLIT approach; integration of the abilities of naturally evolved life forms such as sensing and actuating into bio-hybrid system. Neurofeedback training shows the features of sensing and actuating when the patient's brainwave signals are received by the brainwave reading headset. These brainwave signals are measured and stimulate the audio, visual or combined audio-visual feedback on the computer screen. Then, the patient will respond through brain adjustments when information about how to function are available on that audio, visual or combined audio-visual feedback. Therefore, this research study practices the neurofeedback training in implementing the EVLIT.

ii) How neurofeedback training be used to increase the attention?

The patient's brain is given training using neurofeedback to increase the attention span.

iii) What are the effects of using neurofeedback training in the Quran Memorization Tool?

The adaptation of neurofeedback training concept in the QMT is effective in enhancing the HFAs' attention performance. This is proved through the results obtained during the experimental evaluation.

6.5 Research Limitation

The research limitations of this research study are as follows:

1. The QMT was only tested for investigating the attention level of the HFAs during the memorization of Quran verses and not for investigating the meditation level. Hence, the QMT not consider the meditation values generated by the NeuroSky MindWave headset.
2. The QMT was only applied to the high-functioning autistics and not for low-functioning autistics or students with other learning disabilities.
3. The QMT was only evaluated by using the *sura al-Jumu'ah* and not other suras those has not yet memorized by the HFA students.
4. The QMT adapted a part of the neurofeedback training approach and not adapt the motor response approach.
5. The QMT was only focus on providing videos (the HFA's interested activity) not the drawings as their rewards or motivation.

6.6 Suggestion for Future Enhancement

Through researcher's observation and the evaluation conducted among the HFA students, the effectiveness and efficiency of the QMT were shown. Although the results of the experimental evaluation proved the effectiveness of the QMT in enhancing the HFAs' attention performance during memorization the Quran verses, there are still more improvements those can be considered for further enhancement of the QMT functionalities to elicit better results in sustaining the HFA's attention performance.

1. The development of the QMT also considers the meditation level, so that the attention scores can be compared to the meditation scores to observe the relation between level of mental attention and level of mental relaxation.
2. The QMT is designed to fit the needs of all students with learning disabilities by providing more functionality for the visual feedback, audio feedback, verbal response, motor response, and various types of rewards.
3. In the evaluation part, various suras those has not yet memorized by the HFA students can be tested to observe the differences of the HFAs' attention level during the memorization.
4. The QMT can provide various activities to be chosen by students as their reward such as drawings, games, and video songs to motivate them and elevate their attention to the higher level.

REFERENCES

A'ishah, A. S., & Hardaker, G. (2013). The madrasah concept of Islamic pedagogy. *Educational Review*, *65*(3), 342–356.

Ab. Halim, T. (2007). Islamic Education teachers' perceptions of the teaching of akhlaq in Malaysian secondary schools. *Journal of Moral Education*, *36*(3), 371–386. http://doi.org/http://dx.doi.org/10.1080/03057240701553347

Abdul Hafiz, A., Hussin, S., Azmi Shah, S., Sulaiman Shakib, M. N., Kamarul Azmi, J., & Abdul Basit, S. @Darawi. (2005). *Sistem Pembelajaran Dan Kaedah Hafazan Al-Qur'an Yang Efektif: Satu Kajian Di Kuala Lumpur Dan Terengganu*. Universiti Teknologi Malaysia.

Abdul Hafiz, A., & Norhanan, A. R. (2010). Kaedah hafazan al-quran sistem turki: kajian di tahfiz al-quran darul tuba. *Jurnal Teknologi*, *2*.

AbilityNet. (2010). Autism and Computing for Children Under: How can a computer help. Retrieved August 23, 2016, from https://www.abilitynet.org.uk/play/documents/AutismandComputingfactsheetv4Play.pdf

Allison, B. Z., Dunne, S., Leeb, R., Millán, J. del R., & Nijholt, A. (Eds.). (2012). *Towards Practical Brain-Computer Interfaces*. New York: Springer Science & Business Media.

Association, A. P., & others. (2013). *Diagnostic and statistical manual of mental disorders, (DSM-5®)*. American Psychiatric Pub.

Azizah, H. (2012). Pengajian Asuhan Tilawah Alquran 1. Kuala Lumpur: Open University Malaysia.

Azmil, H., Ab. Halim, T., & Misnan, J. (2013). Latar Belakang Guru Tahfiz Dan Amalan Kaedah Pengajaran Tahfiz Al-Quran Di Malaysia. *Online Journal of Islamic Education*, *1*(1).

Barendse, E. M., Hendriks, M. P., Jansen, J. F., Backes, W. H., Hofman, P. A., Thoonen, G., … Aldenkamp, A. P. (2013). Working memory deficits in high-functioning adolescents with autism spectrum disorders: neuropsychological and neuroimaging correlates. *Journal of Neurodevelopmental Disorders*, *5*, 14. http://doi.org/10.1186/1866-1955-5-14

Barrett, S., Prior, M., & Manjiviona, J. (2004). Children on the borderlands of autism: differential characteristics in social, imaginative, communicative and repetitive behaviour domains. *Autism : The International Journal of Research and Practice*, *8*(1), 61–87. http://doi.org/10.1177/1362361304040640

Becerra, J., Fernandez, T., Harmony, T., Caballero, M. I., Garcia, F., Fernandez-Bouzas, A., … Prado-Alcalá, R. A. (2006). Follow-up study of learning-disabled children treated with neurofeedback or placebo. *Clinical EEG and Neuroscience*, *37*(3), 198–203. http://doi.org/10.1177/155005940603700307

Bernad-Ripoll, S. (2007). Using a self-as-model video combined with Social Stories™ to help a child with Asperger syndrome understand emotions. *Focus on Autism and Other Developmental Disabilities*, *22*(2), 100–106.

Bilikis, B., Nazean, J., & Rodina, A. (2015). Visual Hybrid Development Learning System (VHDLS) Framework for Children with Autism. *Journal of Autism and Developmental Disorders*, *45*(10), 3069–3084. http://doi.org/10.1007/s10803-015-

2469-7

Billstedt, E., Gillberg, C., & Gillberg, C. (2005). Autism after Adolescence: Population-based 13- to 22-year Follow-up Study of 120 Individuals with Autism Diagnosed in Childhood. *Journal of Autism and Developmental Disorders*, *35*(3), 351–360. http://doi.org/10.1007/s10803-005-3302-5

Boch, W. (2011). *Living Technology/ Artificial Systems/ Embodied Evolution*. Brussels. Retrieved from http://cordis.europa.eu/fp7/ict/fet-proactive/docs/shapefetip-wp2013-03_en.pdf

Bölte, S., Holtmann, M., Poustka, F., Scheurich, A., & Schmidt, L. (2007). Gestalt perception and local-global processing in high-functioning autism. *Journal of Autism and Developmental Disorders*, *37*(8), 1493–504. http://doi.org/10.1007/s10803-006-0231-x

Bonde, E. (2000). Comorbidity and subgroups in childhood autism. *European Child & Adolescent Psychiatry*, *9*(1), 7–10.

Bourgeron, T. (2009). A synaptic trek to autism. *Current Opinion in Neurobiology*, *19*(2), 231–4. http://doi.org/10.1016/j.conb.2009.06.003

Bouvet, L., Donnadieu, S., Valdois, S., Caron, C., Dawson, M., & Mottron, L. (2014). Veridical mapping in savant abilities, absolute pitch, and synesthesia: An autism case study. *Frontiers in Psychology*, *5*. http://doi.org/10.3389/fpsyg.2014.00106

Boyle, H. N. (2006). Memorization and Learning in Islamic Schools. *Comparative Education Review*, *50*(3), 478–495. http://doi.org/10.1086/504819

Bredeche, N. (2014). Embodied evolutionary robotics with large number of robots. *Proceedings of the Fourteenth International Conference on the Synthesis and Simulation of Living Systems (ALIFE 2014)*, (1), 272–273. http://doi.org/10.7551/978-0-262-32621-6-ch044

Bredekamp, S. (2014). *Effective Practices in Early Childhood Education: Building a Foundation*. Upper Saddle River, NJ: Pearson.

Brok, J. C. J., & Barakova, E. I. (2010). Engaging autistic children in imitation and turn-taking games with multiagent system of interactive lighting blocks. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 6243 LNCS, pp. 115–126). http://doi.org/10.1007/978-3-642-15399-0_11

Bryson, S. E., Wainwright-Sharp, J. A., & Smith, I. M. (1990). Autism: a developmental spatial neglect syndrome? *Advances in Psychology*, *69*, 405–427.

Burack, J. A. (1994). Selective attention deficits in persons with autism: Preliminary evidence of an inefficient attentional lens. *Journal of Abnormal Psychology*, *103*(3), 535–543. http://doi.org/10.1037/0021-843X.103.3.535

Burack, J. A., Enns, J. T., Stauder, J. E. A., Mottron, L., & Randolph, B. (1997). Attention and autism: Behavioral and electrophysiological evidence. *Handbook of Autism and Pervasive Developmental Disorders*, *2*, 226–247.

Cannon, R., & Lubar, J. (2011). Long-term effects of neurofeedback training in anterior cingulate cortex: A short follow-up report. *Journal of Neurotherapy*, *15*(2), 130–150.

Casey, B. J., Gordon, C. T., Mannheim, G. B., & Rumsey, J. M. (1993). Dysfunctional attention in autistic savants. *Journal of Clinical and Experimental Neuropsychology*, *15*, 933–946. http://doi.org/10.1080/01688639308402609

Chubykin, A. A., Liu, X., Comoletti, D., Tsigelny, I., Taylor, P., & Südhof, T. C.

(2005). Dissection of synapse induction by neuroligins effect of a neuroligin mutation associated with autism. *Journal of Biological Chemistry*, *280*(23), 22365–22374.

Chung, K.-M., Reavis, S., Mosconi, M., Drewry, J., Matthews, T., & Tassé, M. J. (2007). Peer-mediated social skills training program for young children with high-functioning autism. *Research in Developmental Disabilities*, *28*(4), 423–36. http://doi.org/10.1016/j.ridd.2006.05.002

Coben, R. (2006). Hemoencephalography for autistic spectrum disorder. In *14th Annual Conference of the International Society for Neuronal Regulation, Atlanta, Georgia*.

Coben, R., Linden, M., & Myers, T. E. (2010). Neurofeedback for autistic spectrum disorder: a review of the literature. *Applied Psychophysiology and Biofeedback*, *35*(1), 83–105. http://doi.org/10.1007/s10484-009-9117-y

Coleman, D. (1998). A Use Case Template: draft for discussion. *Fusion Newsletter*, 1–6. Retrieved from http://www.engr.sjsu.edu/~fayad/current.courses/cmpe202-Fall2009/docs/lecture3/CmpE202-22-UC-Template-Ex-L3-3g.pdf

Collura, T. F., Guan, J., Tarrant, J., Bailey, J., & Starr, F. (2010). EEG Biofeedback Case Studies Using Live Z-Score Training and a Normative Database. *Journal of Neurotherapy*, *14*, 22–46. http://doi.org/10.1080/10874200903543963

CORDIS. (2011). What is Evolving Living Technologies. Retrieved June 25, 2016, from http://cordis.europa.eu/fp7/ict/fet-proactive/evlit_en.html

Courchesne, E., Pierce, K., Schumann, C. M., Redcay, E., Buckwalter, J. a, Kennedy, D. P., & Morgan, J. (2007). Mapping early brain development in autism. *Neuron*, *56*(2), 399–413. http://doi.org/10.1016/j.neuron.2007.10.016

Crane, L., & Goddard, L. (2008). Episodic and semantic autobiographical memory in adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(3), 498–506.

Crane, L., Pring, L., Jukes, K., & Goddard, L. (2012). Patterns of autobiographical memory in adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *42*, 2100–2112. http://doi.org/10.1007/s10803-012-1459-2

Creswell, J. W., & Plano Clark, V. L. (2007). Designing and Conducting Mixed Methods Research. *Australian and New Zealand Journal of Public Health*, *31*(4), 388–388. http://doi.org/10.1111/j.1753-6405.2007.00096.x

Crowley, K., & McDermott, J. (2015). Mapping brain signals to music via executable graphs. *Creative Commons Attribution 3.0 Unported*.

Crowley, K., Sliney, A., Pitt, I., & Murphy, D. (2010). Evaluating a brain-computer interface to categorise human emotional response. In *Proceedings - 10th IEEE International Conference on Advanced Learning Technologies, ICALT 2010* (pp. 276–278). http://doi.org/10.1109/ICALT.2010.81

Dave, D. M., & Fernandez, J. M. (2015). Rising Autism Prevalence: Real or Displacing Other Mental Disorders? Evidence from Demand for Auxiliary Healthcare Workers in California. *Economic Inquiry*, *53*(1), 448–468.

Dedeke, a., & Lieberman, B. (2006). Qualifying use case diagram associations. *Computer*, *39*(6), 23–29. http://doi.org/10.1109/MC.2006.206

Desti Widiani. (2015). *Pendidikan Karakter Bagi Anak Autis Di Sekolah Khusus Taruna Al-Qur'an Yogyakarta*. UIN Sunan Kalijaga. Retrieved from http://digilib.uin-suka.ac.id/15938/1/BAB I%2C V%2C DAFTAR PUSTAKA.pdf

Diane, T. D., Colker, L. J., & Heroman, C. (2010). The Creative Curriculum for Preschool. Florida: Florida Department of Education. Retrieved from http://www.floridaearlylearning.com/sites/www/Uploads/files/Providers/VPK Curriculum/CreativeCurriculum.pdf

Dini Farhana, B., & Melati, S. (2011). The effect of sound therapy in increasing calmness and reducing stress on working Muslim women in Malaysia. *Procedia - Social and Behavioral Sciences*, *30*.

Duschek, S., Schuepbach, D., Doll, A., Werner, N. S., & Del Paso, G. A. R. (2011). Self-regulation of cerebral blood flow by means of transcranial doppler sonography biofeedback. In *Annals of Behavioral Medicine* (Vol. 41, pp. 235–242). http://doi.org/10.1007/s12160-010-9237-x

Duvinage, M., Castermans, T., Petieau, M., Hoellinger, T., Cheron, G., & Dutoit, T. (2013). Performance of the Emotiv Epoc headset for P300-based applications. *Biomedical Engineering Online*, *12*(1), 56. http://doi.org/10.1186/1475-925X-12-56

Edelson, S. M. (n.d.). Self-Stimulatory Behavior. Retrieved from http://www.autism.com/symptoms_self-stim

Egelhoff, K., & Lane, A. E. (2013). Brief report: Preliminary reliability, construct validity and standardization of the Auditory Behavior Questionnaire (ABQ) for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *43*(4), 978–984. http://doi.org/10.1007/s10803-012-1626-5

EMOTIV. (2011). Emotiv Hardware. *EMOTIV*. San Francisco: EMOTIV. Retrieved from http://emotiv.com/

Farmer, M. (2000). Language and social cognition in children with specific language impairment. *Journal of Child Psychology and Psychiatry*, *41*(05), 627–636.

Fava, L., & Strauss, K. (2010). Multi-sensory rooms: Comparing effects of the Snoezelen and the Stimulus Preference environment on the behavior of adults with profound mental retardation. *Research in Developmental Disabilities*, *31*(1), 160–171. http://doi.org/10.1016/j.ridd.2009.08.006

Fernández, T., Harmony, T., Fernández-Bouzas, A., Díaz-Comas, L., Prado-Alcalá, R. A., Valdés-Sosa, P., … others. (2007). Changes in EEG current sources induced by neurofeedback in learning disabled children. An exploratory study. *Applied Psychophysiology and Biofeedback*, *32*(3-4), 169–183. http://doi.org/10.1007/s10484-007-9044-8

Frei, E., Gamma, A., Pascual-Marqui, R., Lehmann, D., Hell, D., & Vollenweider, F. X. (2001). Localization of MDMA-induced brain activity in healthy volunteers using low resolution brain electromagnetic tomography (LORETA). *Human Brain Mapping*, *14*(3), 152–165. http://doi.org/10.1002/hbm.1049

Fujiki, M., Brinton, B., Morgan, M., & Hart, C. H. (1999). Withdrawn and sociable behavior of children with language impairment. *Language, Speech, and Hearing Services in Schools*, *30*(2), 183–195.

Furqanworks. (2014). *Kaedah Jibril*. Kajang.

Garber, K. (2007). Neuroscience. Autism's cause may reside in abnormalities at the synapse. *Science (New York, NY)*, *317*(5835), 190–191.

Gillberg, C., Cederlund, M., Lamberg, K., & Zeijlon, L. (2006). Brief report:"the autism epidemic". The registered prevalence of autism in a Swedish urban area. *Journal of Autism and Developmental Disorders*, *36*(3), 429–435.

Goldstein, G., Johnson, C. R., & Minshew, N. J. (2001). Attentional Processes in Autism. *Journal of Autism and Developmental Disorders*, *31*, 433–440. http://doi.org/10.1023/A:1010620820786

Graham, L. (1998). *The Principles of Interactive Design* (2nd ed.). International Thomson Publishing ©1998.

Groom, M. J., Scerif, G., Liddle, P. F., Batty, M. J., Liddle, E. B., Roberts, K. L., … Hollis, C. (2010). Effects of motivation and medication on electrophysiological markers of response inhibition in children with attention-deficit/hyperactivity disorder. *Biological Psychiatry*, *67*(7), 624–31. http://doi.org/10.1016/j.biopsych.2009.09.029

Guided Ways Technologies Ltd. (2013). iQuran. Guided Ways Technologies Ltd. Retrieved from https://itunes.apple.com/us/app/iquran/id285946052?mt=8

Halimah, A. (2008). Profil Profesional Hafiz Al-Quran. Retrieved April 16, 2016, from http://drhalimahali.blogspot.my/2008/09/profil-profesional-hafiz-al-quran.html

Hammer, B. U., Colbert, A. P., Brown, K. A., & Ilioi, E. C. (2011). Neurofeedback for insomnia: A pilot study of Z-score SMR and individualized protocols. *Applied Psychophysiology Biofeedback*, *36*(4), 251–264. http://doi.org/10.1007/s10484-011-9165-y

Hammond, D. C. (2007). What Is Neurofeedback? *Journal of Neurotherapy*, *10*(4), 25–36. http://doi.org/10.1300/J184v10n04

Hammond, D. C. (2008). Investigations in Neuromodulation , Neurofeedback and Applied Neuroscience What Is Neurofeedback ? *Journal of Neurotherapy*, *10(4)*, 37–41. http://doi.org/10.1300/J184v10n04

Hammond, D. C. (2010). LENS Neurofeedback Treatment of Anger: Preliminary Reports. *Journal of Neurotherapy*, *14*(2), 162–169. http://doi.org/10.1080/10874201003767213

Hammond, D. C. (2011). What is Neurofeedback: An Update. *Journal of Neurotherapy*, *15*(4), 305–336. http://doi.org/10.1080/10874208.2011.623090

Haq, M. I. (2014). Terapi al-Qur'an untuk Anak Autis di Sekolah Khusus Autis Taruna al-Qur'an Yogyakarta. Retrieved August 16, 2016, from http://itsbatulhaq.blogspot.my/2014/11/terapi-al-quran-untuk-anak-autis-di.html

Heinrich, H., Gevensleben, H., Freisleder, F. J., Moll, G. H., & Rothenberger, A. (2004). Training of slow cortical potentials in attention-deficit/hyperactivity disorder: Evidence for positive behavioral and neurophysiological effects. *Biological Psychiatry*, *55*, 772–775. http://doi.org/10.1016/j.biopsych.2003.11.013

Hong, C., & Lee, I. (2012). Effects of Neurofeedback Training on Attention in Children with Intellectual Disability. *Journal of Neurotherapy*, *16*(2), 110–122. http://doi.org/10.1080/10874208.2012.677666

Ingersoll, B., & Schreibman, L. (2006). Teaching reciprocal imitation skills to young children with autism using a naturalistic behavioral approach: Effects on language, pretend play, and joint attention. *Journal of Autism and Developmental Disorders*, *36*(4), 487–505. http://doi.org/10.1007/s10803-006-0089-y

ISSP. (2013). Living and Intelligent Technology. Retrieved May 23, 2016, from http://www.issp.center/living-technologies/

Jacobs, E. H. (2005). Neurofeedback treatment of two children with learning, attention, mood, social, and developmental deficits. *Journal of Neurotherapy*, *9*(4), 55–70. http://doi.org/10.1300/J184v09n04_06

Jamain, S., Quach, H., Betancur, C., Råstam, M., Colineaux, C., Gillberg, I. C., … others. (2003). Mutations of the X-linked genes encoding neuroligins NLGN3 and NLGN4 are associated with autism. *Nature Genetics*, *34*(1), 27–29.

Johnston, S. J., Boehm, S. G., Healy, D., Goebel, R., & Linden, D. E. J. (2010). Neurofeedback: A promising tool for the self-regulation of emotion networks. *NeuroImage*, *49*(1), 1066–1072. http://doi.org/10.1016/j.neuroimage.2009.07.056

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, *2*(3), 217–250.

Katona, J., Farkas, I., Ujbanyi, T., Dukan, P., & Kovari, A. (2014). Evaluation of the NeuroSky MindFlex EEG headset brain waves data. In *SAMI 2014 - IEEE 12th International Symposium on Applied Machine Intelligence and Informatics, Proceedings* (pp. 91–94). http://doi.org/10.1109/SAMI.2014.6822382

Kernbach, S., Häbe, D., Kernbach, O., Thenius, R., Radspieler, G., Kimura, T., & Schmickl, T. (2013). Adaptive collective decision-making in limited robot swarms without communication. *The International Journal of Robotics Research*, *32*(1), 35–55. http://doi.org/10.1177/0278364912468636

Kouijzer, M. E. J., de Moor, J. M. H., Gerrits, B. J. L., Congedo, M., & van Schie, H. T. (2009). Neurofeedback improves executive functioning in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *3*(1), 145–162. http://doi.org/10.1016/j.rasd.2008.05.001

Kropp, P., Siniatchkin, M., & Gerber, W. D. (2002). On the pathophysiology of migraine - Links for "empirically based treatment" with neurofeedback. *Applied Psychophysiology Biofeedback*, *27*, 203–213. http://doi.org/10.1023/A:1016251912324

Kuo, Y., & Wang, T. (2013). An english listening learning framework based on the learning emotion. In *International Conference on E-Learning, E-Business, Enterprise Information Systems, & E-Government* (pp. 287–288).

Lamb, J. A., Barnby, G., Bonora, E., Sykes, N., Bacchelli, E., Blasi, F., … others. (2005). Analysis of IMGSAC autism susceptibility loci: evidence for sex limited and parent of origin specific effects. *Journal of Medical Genetics*, *42*(2), 132–137.

Larsen, S., Harrington, K., & Hicks, S. (2006). The LENS (Low Energy Neurofeedback System): A Clinical Outcomes Study on One Hundred Patients at Stone Mountain Center, New York. *Journal of Neurotherapy*, *10*(2-3), 69–78. http://doi.org/10.1300/J184v10n02_06

Larsen, S., & Hartmann, T. (2006). *The healing power of neurofeedback: The revolutionary LENS technique for restoring optimal brain function*. Inner Traditions/Bear & Co.

Leins, U., Goth, G., Hinterberger, T., Klinger, C., Rumpf, N., & Strehl, U. (2007). Neurofeedback for children with ADHD: a comparison of SCP and Theta/Beta protocols. *Applied Psychophysiology and Biofeedback*, *32*(2), 73–88.

Lin, C. Y., Lin, H. H., Jen, Y. H., Wang, L. C., & Chang, L. W. (2011). Interactive Technology Application Program of Experience Learning for Children with Developmental Disabilities. *Advanced Materials Research*, *267*, 259–264. http://doi.org/10.4028/www.scientific.net/AMR.267.259

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology*, *32*(6), 643–654.

Lubar, J. F. (1995). Neurofeedback for the management of attention-

deficit/hyperactivity disorders. In Schwartz & S. Mark (Eds.), *Biofeedback: A practitioner's guide* (2nd ed., pp. 493–522). New York: Guilford Press.

Lubar, J. F., & Shouse, M. N. (1976). EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm (SMR) - A preliminary report. *Biofeedback and Self-Regulation*, *1*(3), 293–306. http://doi.org/10.1007/BF01001170

Lubar, J. F., & Shouse, M. N. (1977). Use of biofeedback in the treatment of seizure disorders and hyperactivity. In *Advances in clinical child psychology* (pp. 203–265). Springer.

M. Edelson, S. (2016). Learning Styles and Autism. Retrieved July 27, 2016, from https://www.autism.com/understanding_learning

Maimun Aqsha, L. (2009). Teaching and learning Arabic language through multicultural approach and applying ICT in pesantren institution. *International Journal of Education and Information Technologies*, *3*(3), 171–178.

Maimun Aqsha, L., Melor, M. Y., Noriah, M. I., Tajul Arifin, M., & Mohammed, D. (2009). The effectiveness of strategies and techniques in teaching and learning Islamic education. *WSEAS Transactions on Information Science and Applications*, *6*(8), 218–224.

Majidi, S. A. (2004). Recitation effect of holy Quran on anxiety of patients before undergoing coronary artery angiography. *J Guilan Univ Med Sci*, *13*(49), 61–67.

Mandryk, R. L., Dielschneider, S., Kalyn, M. R., Bertram, C. P., Gaetz, M., Doucette, A., … Keiver, K. (2013). Games as neurofeedback training for children with FASD. In *Proceedings of the 12th International Conference on Interaction Design and Children - IDC '13* (pp. 165–172). http://doi.org/10.1145/2485760.2485762

Mandy, W., Charman, T., Gilmour, J., & Skuse, D. (2011). Toward specifying pervasive developmental disorder—not otherwise specified. *Autism Research*, *4*(2), 121–131.

Mash, E. J., & Barkley, R. A. (2003). *Child psychopathology*. Guilford Press.

Maskey, M., Warnell, F., Parr, J. R., Le Couteur, A., & McConachie, H. (2013). Emotional and behavioural problems in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *43*(4), 851–9. http://doi.org/10.1007/s10803-012-1622-9

Meghan Graham. (2015). Bag Game. Cranberry: all4mychild. Retrieved from https://www.autismspeaks.org/autism-apps/bag-game

Mikami, A. Y., & Hinshaw, S. P. (2003). Buffers of peer rejection among girls with and without ADHD: The role of popularity with adults and goal-directed solitary play. *Journal of Abnormal Child Psychology*, *31*(4), 381–397.

Minshew, N. J., Luna, B., & Sweeney, J. a. (1999). Oculomotor evidence for neocortical systems but not cerebellar dysfunction in autism. *Neurology*, *52*(5), 917–917. http://doi.org/10.1212/WNL.52.5.917

Mirsky, A. F. (1987). Behavioral and psychophysiological markers of disordered attention. *Environmental Health Perspectives*. http://doi.org/10.2307/3430449

Mirsky, A. F., Anthony, B. J., Duncan, C. C., Ahearn, M. B., & Kellam, S. G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review*, *2*(2), 109–145. http://doi.org/10.1007/BF01109051

Miyake, C. (2014). Autism Learning Games: Camp Discovery. United States: Center for Autism and Related Disorders, Inc. Retrieved from

https://itunes.apple.com/us/app/autism-learning-games-camp/id585678823?mt=8

Mohammad Asraff, A. A.-H. (2011). Kaedah Jibril: Teknik Mudah dan Praktikal Menghafaz al-Quran. Retrieved April 13, 2016, from http://pts.com.my/buku/kaedah-jibril-teknik-mudah-dan-praktikal-menghafaz-al-quran/

Mohammad Asraff, A. A.-H. (2015). *Mudahnya Hafaz Al-Quran Menggunakan Kaedah Jibril*. (A. Muhammad Ezzat & M. Y. Zurina, Eds.) (Edisi Kema). Batu Caves: PTS Millennia. Retrieved from http://ulumquran.blogspot.my/

Mohd Shafie, M. A. (2005). *Kaedah Sistematik Membaca, Melancar dan Menghafaz Juz' 'Amma*. (M. A. Mohd Shafie, Ed.) (1st ed.). Batu Caves: Al-Huffaz Consulting Sdn. Bhd.

Monastra, V. J., Monastra, D. M., & George, S. (2002). The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention-deficit/hyperactivity disorder. *Applied Psychophysiology Biofeedback*, *27*(4), 231–249. http://doi.org/10.1023/A:1021018700609

Moore, M., & Calvert, S. (2000). Brief report: Vocabulary acquisition for children with autism. Teacher or computer instruction. *Journal of Autism and Developmental Disorders*, *30*(4), 359–362. http://doi.org/10.1023/A:1005535602064

Moreno, S., & O'Neal, C. (2000). Tips for Teaching High-Functioning People with Autism. Retrieved August 4, 2016, from https://www.iidc.indiana.edu/pages/Tips-for-Teaching-High-Functioning-People-with-Autism

Murray, D., Lesser, M., & Lawson, W. (2005). Attention, monotropism and the diagnostic criteria for autism. *Autism : The International Journal of Research and Practice*, *9*(2), 139–156. http://doi.org/10.1177/1362361305051398

Mustafa, M., & Cullingford, C. (2008). Teacher autonomy and centralised control: The case of textbooks. *International Journal of Educational Development*, *28*(1), 81–88.

MyAspergersChild.com. (2011). The Learning Style of Aspergers Students. Retrieved August 2, 2016, from http://www.myaspergerschild.com/2011/04/learning-style-of-aspergers-students.html

MyQuranStation. (2012). *Surat Al Baqarah Full by Sheikh Mishary Rashid Al-Afasy*. Indonesia. Retrieved from www.youtube.com/user/MyQuranSTaTiOn

NeuroSky. (2014). Brainwave Sensing Headset. San Jose: NeuroSky, Inc. Retrieved from http://store.neurosky.com/pages/mindwave

Neurosky. (2014). Neurosky Mindwave. *Www.neurosky.com*. Retrieved from http://store.neurosky.com/products/mindwave-1

Ng, F. (2014). Memorization Techniques: Memorizing Methods For Different Learning Styles! Retrieved August 18, 2016, from https://blog.udemy.com/memorization-techniques/

Nydén, a, Gillberg, C., Hjelmquist, E., & Heiman, M. (1999). Executive function/ attention deficits in boys with Aspergger syndrome, attention disorder and reading/ writing disorder. *Autism*, *3*(3), 213–228. http://doi.org/10.1177/1362361399003003002

Ochs, L. (2006). The Low Energy Neurofeedback System (LENS):Theory, Background, and Introduction. *Journal of Neurotherapy*, *10*(2/3), 41–58. http://doi.org/10.1300/J184v10n02

Parasuraman, R. (1979). Memory load and event rate control sensitivity decrements in

sustained attention. *Science (New York, N.Y.)*, *205*(4409), 924–7. http://doi.org/10.1126/science.472714

Patten, E., & Watson, L. R. (2013). Interventions Targeting Attention in Young Children With Autism. *American Journal of Speech-Language Pathology*, *20*, 60–69. http://doi.org/10.1044/1058-0360(2010/09-0081)The

Ploog, B. O., Scharf, A., Nelson, D., & Brooks, P. J. (2013). Use of computer-assisted technologies (CAT) to enhance social, communicative, and language development in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *43*(2), 301–322. http://doi.org/10.1007/s10803-012-1571-3

Porayska-Pomsta, K., Frauenberger, C., Pain, H., Rajendran, G., Smith, T., Menzies, R., … others. (2012). Developing technology for autism: an interdisciplinary approach. *Personal and Ubiquitous Computing*, *16*(2), 117–127.

Potegal, M., Carlson, G., Margulies, D., Gutkovitch, Z., & Wall, M. (2009). Rages or temper tantrums? The behavioral organization, temporal characteristics, and clinical significance of angry-agitated outbursts in child psychiatry inpatients. *Child Psychiatry and Human Development*, *40*(4), 621–636.

Prior, M. R., Gajzago, C. C., & Knox, D. T. (1976). An epidemiological study of autistic and psychotic children in the four eastern states of Australia. *Australasian Psychiatry*, *10*(2), 173–184.

Querlioz, D., Bichler, O., Dollfus, P., & Gamrat, C. (2013). Immunity to device variations in a spiking neural network with memristive nanodevices. *IEEE Transactions on Nanotechnology*, *12*(3), 288–295. http://doi.org/10.1109/TNANO.2013.2250995

Quill, K. A. (1995). *Teaching Children with Autism: Strategies to Enhance Communication and Socialization*. (M. A. Terry, B. Burgower, & D. M. Flis, Eds.). United States: Delma Publishers Inc.

Rajendran, G., & Mitchell, P. (2007). Cognitive theories of autism. *Developmental Review*, *27*(2), 224–260. http://doi.org/10.1016/j.dr.2007.02.001

Ricketts, J., Jones, C. R. G., Happé, F., & Charman, T. (2012). Reading Comprehension in Autism Spectrum Disorders: The Role of Oral Language and Social Functioning. *Journal of Autism and Developmental Disorders*. http://doi.org/10.1007/s10803-012-1619-4

Roblyer, M. D. (2006). *Integrating educational technology into teaching*. *Idea* (Vol. 2nd ed). Retrieved from http://www.wilmu.edu/courses/syllabipdf/MED7710_Generic.pdf

Rubinstein, J. S., Meyer, D. E., & Evans, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 763–797. http://doi.org/10.1037/0096-1523.27.4.763

Sabki, A. A., & Hardaker, G. (2013). The madrasah concept of Islamic pedagogy. *Educational Review*, *65*(3), 342–356. http://doi.org/10.1080/00131911.2012.668873

Sachlis, A., & Carpentier, D. (2015). Communication Toolbox. Manassas, Virginia: Arahan Technology Solutions. Retrieved from http://www.communicationtoolbox.org/

SAHO. (2015). Chapter five: A Historical Overview of Madressa Education.

Saini, N., & Agarwal, R. (2015). Neurofeedback as an Intervention for Brain Abilities

Enhancement. *International Journal of Advanced Research in Computer Engineering & Technology*, *4*(5), 1884–1886.

Sanoma Media. (2016). LetterSchool. Netherlands, Amsterdam: Sanoma Media. Retrieved from https://www.autismspeaks.org/autism-apps/letterschool

Sansosti, F. J., & Powell-Smith, K. A. (2010). *High-functioning autism/Asperger syndrome in schools: Assessment and intervention*. Guilford Press.

Schreibman, L., & Stahmer, A. (2006). Is Autism on the Rise. *American Educator*, *36*.

Schug, J. (2011). Circles - Memory Test. United Kingdom: Appogeum.com Limited. Retrieved from http://www.oneplaceforspecialneeds.com/main/library_special_needs_apps.html

Sedek, A., Mustaffa, A., & Khadher, A. (2015). Module of Al-Quran Memorization According to Capability and Period. In *International Proceedings of Economics Development and Research* (Vol. 83, p. 82). IACSIT Press.

Shafiei, N., Salari, S., Sharifi, M., & others. (2011). Camparison between hearing the Quran Arabic Voice and Arabic voice with Persian Meaning on Decreasing the anxiety and Vital Sighns Stabilization of Patients Befor induction of Anesthesia. *Quran & Medicine*, *1*(1 [English]), 11–15.

Shipley-Benamou, R., Lutzker, J. R., & Taubman, M. (2002). Teaching Daily Living Skills to Children with Autism Through Instructional Video Modeling. *Journal of Positive Behavior Interventions*, *4*(3), 166–177. http://doi.org/10.1177/10983007020040030501

Silverman, J. L., Yang, M., Lord, C., & Crawley, J. N. (2010). Behavioural phenotyping assays for mouse models of autism. *Nature Reviews. Neuroscience*, *11*(7), 490–502. http://doi.org/10.1038/nrn2851

Silverman, L. B., Bennetto, L., Campana, E., & Tanenhaus, M. K. (2010). Speech-and-gesture integration in high functioning autism. *Cognition*, *115*(3), 380–93. http://doi.org/10.1016/j.cognition.2010.01.002

Siti Iradah, I., & Rabiah, A. K. (2011). EduTism : An Assistive Educational System for the Treatment of Autism Children. In B. Z. Halimah, P. Robinson, M. Petrou, P. Olivier, T. K. Shih, S. Velastin, & I. Nyström (Eds.), *Visual Informatics: Sustaining Research and Innovations* (pp. 193–204). Selangor: Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-642-25200-6_19

Siti Murtosiah. (2016). *Penerapan Media Al-Quran Digital Pen (Al-Qolam) Terhadap Hasil Belajar Siswa Pada Mata Pelajaran Al-Quran Hadits Di Kelas IV Mi Raudhatul Ulum Sakatiga (Skripsi)*. UIN Raden Fatah Palembang.

Siti Patonah, M., M. Y. Zulkifli, M. Y., & Durriyyah Sharifah, H. A. (2014). Pengajaran Dan Pembelajaran Al-Quran Bagi Golongan Kelainan Upaya Mental: Analisis Dari Sumber Tradisi Islam. *Jurnal Islam Dan Masyarakat Kontemporari*, *8*, 153–168. Retrieved from https://journal.unisza.edu.my/jimk/index.php/jimk/article/view/122

Siti Patonah, M., Zulkifli, M. Y., & Durriyyah Sharifah, H. A. (2013). Sound Therapy through Quranic Recitation in Dealing with Emotional and Verbal Motor Skills Problems of Children with Autism. *QURANICA International Journal of Quranic Research*, *5*(2), 53–72.

Smith, M. D., & others. (1995). *A Guide to Successful Employment for Individuals with Autism.* ERIC.

Smykovsky, N. (2015). ABC, Talk with Me! Ukraine: ABC, Talk with Me! Retrieved from https://www.autismspeaks.org/autism-apps/abc-talk-me

Steiner, N. J., Frenette, E. C., Rene, K. M., Brennan, R. T., & Perrin, E. C. (2014). Neurofeedback and cognitive attention training for children with attention-deficit hyperactivity disorder in schools. *Journal of Developmental and Behavioral Pediatrics : JDBP*, *35*, 18–27. http://doi.org/10.1097/DBP.0000000000000009

Stevens, M. C., Fein, D., & Waterhouse, L. H. (2000). Season of birth effects in autism. *Journal of Clinical and Experimental Neuropsychology*, *22*(3), 399–407.

Strehl, U., Leins, U., Goth, G., Klinger, C., Hinterberger, T., & Birbaumer, N. (2006). Self-regulation of slow cortical potentials: a new treatment for children with attention-deficit/hyperactivity disorder. *Pediatrics*, *118*(5), e1530–1540. http://doi.org/10.1542/peds.2005-2478

Sung, Y.-S., Cho, K.-E., & Um, K.-H. (2011). A Framework for Electroencephalogram Process at Real-Time using Brainwave. *Journal of Korea Multimedia Society*, *14*(9), 1202–1209.

Szegletes, L., & Forstner, B. (2013). An Introduction to a Neurofeedback - based Self - Rewarding Framework on Mobile Devices using Modern HCIs. *International Journal of Education and Information Technologies*, *1*(7), 27–34. http://doi.org/10.1007/978-3-642-29044-2

Takahashi, J., Gyoba, J., & Yamawaki, N. (2013). Brief report: Effect of spatial complexity on visual short-term memory and self-reported autistic-like traits in typically developed individuals. *Journal of Autism and Developmental Disorders*, *43*(7), 1725–1731. http://doi.org/10.1007/s10803-012-1711-9

Thenius, R., Zahadat, P., & Schmickl, T. (2013). EMANN - a model of emotions in an artificial neural network. *Advances in Artificial Life, ECAL 2013*, *12*(SEPTEMBER), 830–837. http://doi.org/10.7551/978-0-262-31709-2-ch122

Thomas, K. P., Vinod, A. P., & Guan, C. (2013). Design of an online EEG based neurofeedback game for enhancing attention and memory. In *Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (Vol. 2013, pp. 433–436). http://doi.org/10.1109/EMBC.2013.6609529

Thompson, L., Thompson, M., & Reid, A. (2010). Neurofeedback outcomes in clients with Asperger's syndrome. *Applied Psychophysiology and Biofeedback*, *35*(1), 63–81. http://doi.org/10.1007/s10484-009-9120-3

Toomim, H., & Carmen, J. (2009). Hemoencephalography. Photon-Based Blood Flow Neurofeedback. In *Introduction to Quantitative EEG and Neurofeedback* (pp. 167–194). http://doi.org/10.1016/B978-0-12-374534-7.00007-1

Toomim, H., Mize, W., Kwong, P. C., Toomim, M., Marsh, R., Kozlowski, G. P., … Rémond, A. (2005). Intentional Increase of Cerebral Blood Oxygenation Using Hemoencephalography (HEG): An Efficient Brain Exercise Therapy. *Journal of Neurotherapy*, *8*(3), 5–21. http://doi.org/10.1300/J184v08n03_02

Tsatsanis, K. D. (2004). Heterogeneity in Learning Style in Asperger Syndrome and High-Functioning Autism. *Topics in Language Disorders*, *24*(4), 260–270. http://doi.org/http://dx.doi.org/10.1097/00011363-200410000-00004

Turner, M. (1999). Annotation: Repetitive behaviour in autism: A review of psychological research. *Journal of Child Psychology and Psychiatry*, *40*(6), 839–849.

Vernon, D. J. (2005). Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research. *Applied Psychophysiology and Biofeedback*, *30*(4), 347–364. http://doi.org/10.1007/s10484-005-8421-4

W, S. (2015). The Difference Between Education in the East and the West. Retrieved March 20, 2017, from http://studentnewspaper.rectoryschool.org/1859/opinion/the-difference-between-education-in-the-east-and-the-west/

Wagler, P. F., Tangen, U., Maeke, T., & McCaskill, J. S. (2012). Field programmable chemistry: Integrated chemical and electronic processing of informational molecules towards electronic chemical cells. *BioSystems*, *109*(1), 2–17. http://doi.org/10.1016/j.biosystems.2012.01.005

Wainwright, J. A., & Bryson, S. E. (1996). Visual-spatial orienting in autism. *Journal of Autism and Developmental Disorders*, *26*(4), 423–438. http://doi.org/10.1007/BF02172827

Wainwright-Sharp, J. A., & Bryson, S. E. (1993). Visual orienting deficits in high-functioning people with autism. *Journal of Autism and Developmental Disorders*, *23*(1), 1–13. http://doi.org/10.1007/BF01066415

Wan Malini, W. I., Fadhilah, A., Mat Atar, M. A., Mohd Sufian, M. D., Azilawati, R., Wan Mohd Rizhan, W. I., & Suhailan, S. (2010). Development and Innovation of Multimedia Courseware for Teaching and Learning of KAFA Subjects. In *2nd International Conference on Computer Technology and Development* (pp. 100–104).

Wan Noor Hazlina, W. J., & Kamaruzaman, J. (2009a). Using multimedia in teaching Islamic studies. *Journal Media and Communication Studies*, *1*(5), 86–94. Retrieved from http://www.academicjournals.org/jmcs

Wan Noor Hazlina, W. J., & Kamaruzaman, J. (2009b). Using multimedia in teaching Islamic studies. *Journal of Media and Communication Studies*, *1*(5), 86–94.

Wigton, N. L., & Krigbaum, G. (2015). Attention, Executive Function, Behavior, and Electrocortical Function, Significantly Improved With 19-Channel Z-Score Neurofeedback in a Clinical Setting: A Pilot Study. *Journal of Attention Disorders*, 1087054715577135–. http://doi.org/10.1177/1087054715577135

Zandt, F., Prior, M., & Kyrios, M. (2007a). Repetitive behaviour in children with high functioning autism and obsessive compulsive disorder. *Journal of Autism and Developmental Disorders*, *37*(2), 251–259. http://doi.org/10.1007/s10803-006-0158-2

Zandt, F., Prior, M., & Kyrios, M. (2007b). Repetitive behaviour in children with high functioning autism and obsessive compulsive disorder. *Journal of Autism and Developmental Disorders*, *37*(2), 251–9. http://doi.org/10.1007/s10803-006-0158-2

Zawawi Hj. Ahmad. (1996). *Sains dalam pendidikan Islam*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Zuldiah. (2012). Kajian Kaedah Atau Method Hafazan Antara Dua Institusi Tahfiz Al-Quran Di Malaysia. Kuala Lumpur: Open University Malaysia.