

THE EFFECTIVENESS OF MANAGING SPLIT ATTENTION AMONG AUTISTIC CHILDREN USING COMPUTER BASED INTERVENTION

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ABSTRACT

One of the most common problems in autistic children is split attention. Split attention prevents autism children from being able to focus attention on their learning, and tasks. As a result, it is important to identify how to make autistic individuals focus attention on learning. Considering autistic individuals have higher visual abilities in comparing with ordinary people, visual supports are used to enable learning. With the requirement of visual information displays for autistic children, computer based interventions are used. Previous researches indicated that autistic children could be supported effectively by providing a structured and controlled environment using computer based intervention. In order to overcome autism children's split attention problems, design issues should be customized for them. Moving forward towards the research, it is concluded that in addition to the design issues to be considered for the autistic children, teaching issues are also required to be incorporated. This research aimed at providing a computer based application, considering the identified design issues incorporated with the teaching issues based on Fakhri method for the autistic children to manage their split attention. The considered design issues incorporated with teaching issues are evaluated to identify whether they are effective in enhancing autistic children's split attention and learning.

Keywords: Autistic Children, Computer Based Intervention, Split Attention.

INTRODUCTION

Autism is one of the most common pervasive developmental disorders that contain criteria of defects in communication, social interaction, and creative or imaginative play. Nowadays autism is affecting 1.5 million American children and with the growing rate of 10 to 17 percent (Kientz, Hayes, Westeyn, Starner, and Abowd, 2007). Autism is diagnosed between the ages of two and six, and it is four times more likely to occur in boys in comparison with girls. As stated by the National Autism Society of Malaysia (NASOM), the number of autistic people diagnosed has increased 30 percent in three years.

Defined as a complex developmental disability, autism is the result of a neurological disorder that affects the normal brain functioning and influences the development of social interaction and communication skills (American Psychiatric Association, 2000). Because of autistic children disabilities, they encounter various challenges in life. They are unable to understand social cues and their personal safety might be at risk (Myles, Trautman, & Schelvan, 2004). Therefore, autistic children have to be taught special skills to help them cope with their problems.

In order to assist autistic children, visual supports which are cognitive tools are used to enable learning (Hayes et al., 2010). Considering autistic children have higher visual abilities than ordinary people (Ameli, Courchesne, Lincoln, Kaufman, & Grillon, 1988), using visual supports can improve their communication process (Hodges et al., 2006). Responding to autism needs of communications, they must be taught to learn their language effectively and could be able to focus attention on their learning. Supporting autism children in communications and understanding of social situations will help encourage growing awareness of their difficulties (Hanbury, 2005).

One of the most important difficulties of autistic children is learning. Due to autism spectrum disorders, these children cannot focus attention on their learning process. The split attention effect is required to see how the user can learn to use the system by splitting their attention to different source of information (Sweller, Ayres, & Kalyuga, 2011). In this research, we will focus on how to manage autism individuals' split attention while using the computer in their learning. In addition, we will point out how to integrate different sources of information that must be considered (Sweller et al., 2011), so that children's learning occur. Furthermore, the design issues, and teaching issues that are required to be considered for the autistic children are identified in this study.

BASIC CONCEPTS, DEFINITIONS, AND LITERATURE REVIEW

This section offers the basic concepts, and definitions of the study. It provides a review of the literature and related works on the use of computer based interventions in learning and understanding for the children in autism spectrum disorders (ASD), managing split attention among autistic children, and the effectiveness of managing split attention between autistic children using computer based intervention.

Autistic Children

Kientz et al. (2007) label autism as one of the most common pervasive developmental disorders that contain criteria of defects in communication, social interaction, and creative or imaginative play. Wetherby and Prizant (2000) describe the main characteristics of the autistic children's disorders as impairment communication which is the earliest symptom shown as the word (Eigsti, Bennetto, & Dadlani, 2007), delay in language development, using language idiosyncratically and repetitively and not being able to begin or maintain a conversation (Wetherby & Prizant, 2000).

Due to autism children disabilities, they face numerous challenges in life. One of the most important difficulties of autistic children is learning. Many researches had been done to investigate a method for teaching and helping the autistic children most effectively and efficiently (Ramdoss, Lang, Mulloy, et al., 2011; Hetzroni & Tannous, 2004; Ramdoss, Mulloy, et al., 2011; Whalen, Massaro, & Franke, 2009; Simpson, Langone, & Ayres, 2004). Alcantara (1994) proved that providing practice and training in controlled environments for the autistic children is effective. For this purpose, multimedia computer based strategies could be used to present simulated environments containing a structured and controlled setting (Hetzroni & Tannous, 2004). Therefore, in order to facilitate the autism individuals practice and training various skills, computer based intervention is used (Hetzroni & Tannous, 2004).

Computer Based Intervention

Barron, Harmes, and Kemker (2006) note that with the development of computer technology, and decreasing their expenses, computers are used in children's schools and homes commonly. Computers are used as instructional tools in children with or without learning disabilities today (Inan, Lowther, Ross, & Strahl, 2010). As stated by (Ramdoss, Lang, Fragale, et al., 2011), in computer based intervention, the computer provides instructions via offering audio and visual stimuli associated with the target skill. (Mechling, Gast, & Stefane'Barthold, 2003) pointed out that computer based intervention allows learners to interact with the program using external hardware devices such as touch screens, scanners, keyboards and switches (Herskowitz, 2009).

Using Computer Based Intervention among Autistic Children

Computers have been found successful as a teaching instrument for the autistic children (Chen & Bernard-Opitz, 1993; Colby, 1973; Higgins & Boone, 1996; Panyan, 1984). According to several studies, supporting autistic children with computers in a structured and controlled environment, using multilevel interactive functions was found effective in a variety of computer based interventions (Bernard-Opitz, Ross, & Tutas, 1990; Chen & Bernard-Opitz, 1993; Panyan, 1984; Yamamoto & Miya, 1999).

There are several reasons for selecting computer based intervention as a feasible approach in teaching literacy skills to autistic children (Powell, 1996). First of all, research has indicated that autistic children are visual learners and computer based intervention offers visual information displays that are customizable (Bondy & Frost, 1994; Whalen et al., 2010).

Secondly, computer based intervention minimizes the social defects impact on the autistic children and benefits literacy instruction by reducing the children's complexity in the interaction with the teacher (Ramdoss, Mulloy, et al., 2011). Thirdly, research by Lahm (1996) shows that autistic children are highly responsive while using computers that could make academic demands. As a final point, computer based intervention could be used for a particular student's ability level by selecting the appropriate setting in order to utilize individualized instruction (Ramdoss, Mulloy, et al., 2011).

Higgins and Boone (1996) and Panyan (1984) mention that computers are used effectively in teaching different instructional skills to the autistic children. Blischak and Schlosser (2003) found computer based intervention using word processing software as a great way of enhancing the children with autism spelling and frequent word spontaneous. In order to teach vocabulary and grammar to the autistic children Bosseler and Massaro (2003) successfully used computer animated tutor including receptive and expressive language activities.

(Ramdoss, Lang, Mulloy, et al., 2011) used computer based intervention systematically in teaching literacy skills such as reading, and sentence construction with the intention of improving vocal and non-vocal communications of autistic children. Reading and writing skills were enhanced for the autistic children interacting with computers as stated in the study of (Heimann, Nelson, Tjus, & Gillberg, 1995). Fitzgerald, Koury, and Mitchem (2008) reported advances in using computer based intervention in the study field of reading, mathematics, writing, social studies, and science among children with minor or severe disabilities.

Higgins and Boone (1996) emphasize that using computer based intervention among autistic children in classrooms with high numbers of students reduces distractions, establish clear routines, and provides immediate reinforcement, better performance, and faster response collecting. They also indicated that using computer based intervention for children with autism allows performing programs that deliver many necessary functions and instructions (Higgins & Boone, 1996). Research by Chen and Bernard-Opitz (1993) indicated that autistic children had presented more correct answers, and improved behavior skills after using computer based intervention rather than using traditional instruction.

Herskowitz (2009) utilized computer based intervention on the autism spectrum and her study indicated that using computer based intervention for autistic children is more effective in comparison with the traditional skill training methods. This speech pathologist realized that using computer based intervention improves acquisition of many skills such as language and speech, reading, math, auditory processing and life skills (Herskowitz, 2009). Yamamoto and Miya (1999) point out that only a few studies have been done to explore the effectiveness of using computers among autistic children to improve their language skills. Therefore, it is still required to study whether the autistic children could learn specific language skills using computer based intervention in a controlled and structured environment (Hetzroni & Tannous, 2004).

Split Attention Definition

Split attention takes place when learners are required to divide their attention between at least two sources of information (Sweller et al., 2011). For maximum learning and understanding to occur, all disparate sources of information must be integrated as far as possible. The split attention is applied whenever it is more effective for the learner to integrate different sources of essential and non redundant information in a learning strategy (Sweller et al., 2011). Depending on the information source, the reference should be synchronized with the relevant text, or visual presentation, and without such integrated configuration, learning does not happen fast.

The split attention has been used for many diverse categories of learners and in a wide variety of situations using many different types depending on their requirement (Sweller, et al., 2011). If isolated multiple information sources are unlearnable and unintelligible, split attention effect must be facilitated among learners (Sweller et al., 2011). For example, having a circumstance in which a diagram provides all the required information for the learner, and adding text would not be beneficial, then the text should be eliminated. There are many

various forms of split attention effect, but the best effective condition of information display must be chosen for learners.

Reviewing what other researchers have done demonstrates that integrating essential sources of information has a great advantage on learner understanding (Sweller & Cooper, 1985; Tarmizi & Sweller, 1988; Mayer & Moreno, 1998; Pociask & Morrison, 2008; Rose & Wolfe, 2000; Cooper & Sweller, 1987; Sweller & Chandler, 1994). Presenting information in split source form requires learners to search for connection with the information sources if they could not understand them in isolation (Sweller et al., 2011). By integrating disparate sources of information, searching process that need heavy memory functioning could be eliminated largely. Integrating split sources might be done within two sources of information, or more than two information sources (Sweller et al., 2011).

Split Attention While Learning to Use a Computer

One of the most common usages of split attention effect is giving instructions to the learners to use a computer either from a computer screen or computer manual (Sweller, et al., 2011). Sweller et al. (2011) mentioned that learners must read the information and learn how to manipulate different parts of the computer, such as the mouse, or typing a specific text to run the particular application. (Sweller & Chandler, 1994) tested the learners who wanted to learn about a Computer Aided Design (CAD) or Computer Aided Manufacturing (CAM) in two forms of integrated and split source. In the integrated strategy only a modified manual is used which consists of physically integrating text and diagrams, but learners were not allowed to access the computer since all commands relating to the computer screen and keyboard were represented in the manual. On the other hand, in the split source circumstances learners could try out different procedures on the computer as reading the manual. Later on, the evaluation result confirmed that in the integrated group students were showing greater competence in using the computer to solve the primary tasks than students practicing with the equipment physically.

Recent research done by Sweller et al. (2011) indicates that students could effectively learn how to use computer programs by giving all the instructions in an integrated or single module. Cerpa, Chandler, and Sweller (1996) expressed that there is no difference between the presentation of instructions whether it is paper based or on the screen manual. Learners are required to generate some simple mathematical formulae inside the cells in using spreadsheets learning format. In the integrated strategy, all instructions were inserted into the spreadsheets at the most spatially relevant points, within the cells themselves (Cerpa et al., 1996). The physically integrated strategy was found superior in comparison with the split source formatting where the screen based instructions were not integrated.

According to Sweller and Chandler (1994) and Cerpa et al. (1996), the split attention effect takes place using high element interactively materials. As mentioned by Sweller et al. (2011) because of having lots of tasks to be done in spreadsheet learning form such as creating a complex numerical formula, locating the cell, finding the relevant symbol on the keyboard and typing the value, they could be managed to fewer interacting elements. Sweller et al. (2011) also noted that presenting information within the instructions and machinery requires learners' hard memory working, and students feel they ought to divide attention between the machine and instructions. Therefore, the instructions must be presented in an appropriate manner, more intelligible than the split attention format instructions, and without referencing to machinery.

Methods to Overcome Split Attention

Research done by (Sweller, et al., 2011) indicates that problems with the presentation of split information source is facilitated with integration strategy so far. Nevertheless other alternative methods are used to overcome the split attention problem. Directing attention to the proper source of information has been worked out by (Kalyuga, Chandler, & Sweller, 1999) to help learners efficiently in the domain of learning electrical circuits. In order to connect the related diagram with the text, color coding system was used to reduce the visual amount of the required search. In addition, Tabbers, Martens, and Van Merriënboer (2000) found that using visual cueing is an effective strategy to reduce the visual search by isolating the text with colors.

Florax and Ploetzner (2010) grouped text into segments and each segment was labeled with a number corresponding to the relevant diagram, and found out that there is no difference between fully integration strategy and segment-number format in the learning process. As mentioned by Sweller and Chandler (1994), in the fully integration form the text segments were written next to the relevant part of the diagram. Further research showed that both methods were found superior to facilitate the split attention effect, but segment-number strategy had a stronger effect on the learner rather than the fully integration form. As noted by Sweller et al. (2011), the reason of segment-number format effectiveness is having smaller information chunks which are easier for the memory to hold.

Bétrancourt and Bisseret (1998) stated that by placing pictures and text close to each other in their integration, the picture could be over crowded with the inserted text. As an alternative method, the pop-up method is used to avoid the cluttered picture if there are large amounts of text included. In order to solve this problem Bétrancourt and Bisseret suggested inserting the text at the relevant position in the diagram but in hidden form unless the learner clicks on the mouse and the information is displayed. Both methods were found superior outcomes on learning in comparison with the split source format, but in the pop-up display learners made fewer errors and the solution time was quicker and there was more user control.

To support the effectiveness of the pop-up method, Barron et al. (2006) compared the pop-up method with the separated and integrated format. The study demonstrated that the pop-up model and the integrated strategy were superior to the separated method, but by measuring the tasks the pop-up method was found superior to the integrated format. Crooks, White, Srinivasan, and Wang (2008) used the pop-up method in the domain of geography maps and proved that it is also effective to place the text away from the map. The text could appear on a separate screen immediately since the learners click on the specific part of the map, and still could facilitate more learning.

Managing Split Attention

In managing split attention there should be a control over the conditions of applicability from the required information sources. As stated by Sweller et al. (2011), integrating different information sources is done under condition that it is more effective for the learner instead of split format that contains separated materials. The applicability of integrating information sources is when the information is essential and non redundant. Considering that learners could learn only by using one information source, then the physical integration strategy is not required in this situation.

Sweller et al. (2011) point out that the split attention effect is used in various learning domains containing different combination of text, diagrams, pictures and machines such as computers. In managing split attention, intending highest learning and understanding takes place for learners, all different information sources must be integrated as far as possible (Sweller et al., 2011). Sweller et al. (2011) stated that the split attention effect provides the significant instructional design principles to help the designers know how to include the information that must be considered simultaneously.

Therefore, in managing split attention within the information sources the most effective format must be chosen. Whenever the information integration takes place, the structure should contain a clear relation among the information sources, and it should eliminate or reduce any search for the references (Sweller et al., 2011). In addition, learners' working memory should be reduced and they should not search to find a relation within the information sources (Sweller et al., 2011). In brief, in split attention management, there should be a great control through the presented information to avoid split attention and redundancy (Pociask & Morrison, 2008).

Managing Split Attention among Autism Children

According to Wetherby and Prizant (2000), one of the most important difficulties of autistic children in learning is not being able to focus and pay attention to the relevant information and cues. This defect prevents the autistic children from paying attention to the appropriate information source, and focuses the child's attention only on a restricted area in which they

might miss the important notes. Resistance to change as the autistic children characteristics causes the problem of shifting attention within one source to another source (Wetherby & Prizant, 2000). In addition autism children might show a short attention span. Consequently, autism child difficulties have a significant effect on their learning and language development.

As stated by Wetherby and Prizant (2000), because of autistic children disabilities, instructional activities and the information provided for teaching them must be structured in a clear format that makes them focus their attention, and emphasizes the most relevant information. For this objective, using visual supports as a teaching approach for autistic children is suggested by Wetherby and Prizant (2000). Visual aids have been widely successful for autistic children and help them cope with their difficulties in learning, thinking, understanding and communications. As mentioned by Wetherby and Prizant (2000), using visual aids enables autism children to focus attention on the messages. Another advantage is that autistic children could use visual supports as long as they are required to process the information comparing with the oral information presentation especially for children with difficulty in language processing who need extra time to focus.

Visual aids are used in a variety of ways according to the student's level of comprehension. They could be presented from simple form to complex and concrete to abstract. Visual supports include graphic symbols, pictures, photographs, drawing and written language. As stated by Wetherby and Prizant (2000), visual supports were found useful in organizing the children's activity, providing instructions for the children, assisting their understanding, supporting appropriate behavior, teaching social skills and self-control. On the other hand, the main question asked here is how to present the information to the autism children by using visual aids so that it improves their understanding, abilities and responses.

In addition to visual supports, other instructional approaches exist to draw the autistic children attention in learning as noted by Wetherby and Prizant (2000). Giving the autistic children precise information and positive praise about what they did right in their learning could be motivating. Providing opportunities for choosing which practice they prefer might be helpful in autism children learning, and does not frustrate them. In giving oral instruction to the students with autism, it is better to break down the instructions into small steps due to their split attention problems. The fact that autistic children require more time to respond should be taken into account.

In designing and preparing instructional materials for autistic children's learning it is important to consider the child's age, provide reinforcements and rewards, and plan tasks at an appropriate level of difficulty. Using specific examples could give abstract ideas and conceptual thinking to the autistic children while learning. Another method is to use task analysis among children with autism to break complex tasks down into subtasks and reinforce in sequence and small increments. Incorporating colors for the children with autism might be helpful in representing the emotional context.

The Effectiveness of Managing Split Attention among Autism Children using Computer Based Intervention

With the objective of evaluating the effectiveness of managing split attention between autism children, computer based intervention is used to achieve improved learning, task performance for the individuals. A review of the literature on autistic child's defects by Wetherby and Prizant (2000) shows that these children have difficulties in paying attention, language development and handling complex information. Therefore, the main question in this research is how to give instructions to the autistic children in learning to make them focus attention, and avoid splitting attention using computer based intervention.

Wetherby and Prizant (2000) highlighted that in designing instructions the problematic behavior of the children with autism should be considered in order to gain the children's attention. Instruction prepared for the autistic children should be given in a manner to emphasize paying attention, comprehending, and using language in play mode. Incorporating visual material in teaching autistic children is suggested by Wetherby and Prizant (2000) since they are visual learners (Layton, 1988), and visual oriented.

According to Kalyuga et al. (1999) using the color coding technique might be helpful to manage split attention in computer based intervention, because of giving the permission to use a manageable amount of colors. Using manageable amount of colors eliminates the positive effect of color coding technique and avoids significant load on working memory. Consequently, computer based intervention should be designed considering the required design issues and the autistic children's problems and concerns to have more influence and be more effective. Measurement metrics are used to identify whether the system is effective or not (Nielsen, 1994).

Introducing Fakh Method

Fakh method is a method to teach Quran to the deaf individuals. According to (Daud, 2012), this method aims at addressing the lacking issues of learning aids, and teaching materials in the field of Islamic knowledge for deaf children having problem in learning. In this method numbering and coloring techniques are applied to represent each Arabic alphabet, and each Arabic sign in the holy Quran. Numbers and colors are used to avoid confusion and assist the deaf individuals easily learn the Quran. The method shows the pronunciation steps of the each Arabic alphabet, and each Arabic sign by using numbers. Due to the fact that this method of teaching has not been used to teach autistic children, and not implemented either, the intention of this study is to use the same module as Fakh for the autistic, using the computer based application.

Literature Review Discussion and Findings

All in all, it is important to identify how to make autistic individuals focus attention on learning. Considering the autism spectrum disorders, how can we manage their split attention in learning while interacting with the system, and how to integrate different sources of information that must be considered, so that children learning occurs, and how can we reduce their difficulties, and improve their learning and communication skills. Another significant point is to identify how to prepare the design and teaching instructions for the autistic children to make them focus attention on learning their lessons.

From the review study on other researchers work, it is concluded that autistic individuals require providing specific teaching instructions. Besides, each study points at using a particular issue in order to draw these individual attention on learning. Using techniques such as color coding, and segment number strategy, illustrating the essential materials, and avoiding redundancy are proved by different researchers in facilitating the learners split attention. In addition, others insist on preparing instructional materials using visual supports, breaking the tasks (step by step), and providing rewards for motivation in order to improve the understanding abilities and responses of autistic children.

Although there are many diverse studies on how to manage autism children split attention problems in learning, there is still a lack of a computer application in which uses, and incorporates all the pointed reviewed materials simultaneously. The intention of this research is to provide a computer based application based on Fakh method that incorporates all the methods at the same time. Therefore, the main objectives of this research are as follows:

- To identify the design issues, incorporating with the teaching issues that are required to be considered to manage split attention among the autistic children.
- To develop a computer based application based on Fakh method in which it considers the identified design issues, and teaching issues.
- To evaluate the effectiveness of the system on the autistic children's split Attention.

RESEARCH METHODOLOGY

Two main studies were performed in this research; Baseline Study, and Intervention Study. After performing the Baseline Study, the next step is the system Design and Implementation. Since the system is prepared, the Intervention Study starts to evaluate the application.

Baseline Study

The objective of the Baseline stage is to identify needs, establish requirements, obtain knowledge, and be familiarized with the autism spectrum disorders. As a result of this section, the user interface requirements are presented in final.

Identifying Needs

To identify the needs of the research, Interviews, Observations, and Preliminary Study had been performed. Interviews with the autistic children’s parents had been done in order to identify their children’s needs, and get familiar with the challenges in their life. Observations on the autistic children had been done in three sessions with the objective of identifying their learning requirements, familiarizing with the autistic children’s behavior in class, knowing how the teacher teaches the autistic children in class, and how the autistic children interact with the computer.

After the interviews and observations were prepared, a short preliminary study was conducted in Malaysia in October 2011 as a part of the Baseline study. In this preliminary study refer to the interviews had been done with the aim of getting familiar with the autism children’s characteristics and knowledge level, and identifying the learning skills required for them. Accordingly to this study, a few teaching issues that are pointed by autistic children parents are identified to be considered in designing, and preparing instructions for such children as follows:

- Using Phonics, Syllables, Numbers, and Visual Supports
- Teaching One-to-one, and in Sequence.

Establish Requirements

After identifying the needs, in order to produce a set of stable requirements, and to move forward to the design, establishing requirements is needed. In order to establish the requirements PACT (People, Activities, Contexts, and Technologies) Analysis is carried out in which it specifies the People, Activities, Contexts, and Technologies in the research (Benyon, Turner, & Turner, 2005). For this purpose, User Analysis, Task Analysis, Context Analysis, Technology Analysis, and Usability Specifications are done as the steps of PACT Analysis.

After performing the PACT Analysis steps, Usability Specification is done to specify the user requirements from the usability aspect. Moreover, Literature Review, and Preliminary Study are performed to specify the user interface requirements. The Literature Review and the Preliminary Study aim to recognize the required design issues incorporating with the teaching issues to manage autism children’s split attention. Finally, the user interface requirements are offered as a result of the applied methods.

User Analysis

User Analysis contains detecting the user profile that shows the user characteristics (Benyon et al., 2005) which is illustrated from the Baseline Study.

Table 1: User profile

User Profiles	Description
Age	Will range in age from about 5 and maximum 18
Gender	Both male and female which is 12 male, and 1 female in the class.
Physical Limitation	Some students might require help during learning because of having weak hands.
Computer/iPad /Hand-phone Use	Most students used computers, and hand-phones for playing, and some used iPad before.
Motivation	Make the students feel they are in playing condition.
Attitude	This application aims at assisting autistic children in learning Quran. Attitude to use is to make them feel they are enjoying learning, and the application motivates them to focus attention on learning.
Educational Background	The students were elementary school students. Students could speak and understand Malay, and English language. Most of the students know how to use the computer and mouse.

Task Analysis

Task Analysis classifies the tasks required to be carried out in the learning process (Kurniawan, 2001). In this study, Task analysis includes how autistic children will carry out the tasks, which tasks they were able to perform, and whether they were able to achieve the goal. The goal is to be able to focus attention, and finish learning a level, and achieve to another level. The reason for task analysis is to identify where to give instructions to the autistic children, and where they could take turns in learning. In this research task analysis is done in both Baseline study, and Intervention study to identify whether using the application has effect on autistic children's focusing attention. In this research the tasks are broken into the following steps in the paper based, and computer based:

Paper Based Tasks Analysis:

- Students sit on the chair
- Students look at the papers
- Students hold the pencil
- From Level 1 to 8:
- Students listen to Instructions (the researcher holds student's hand, and show directions in learning)
- Repeating Instructions if required
- Students take Turn
- Student finish learning, and leave (this is when students become tired and refuse to learn)

Computer Based Tasks Analysis:

- Students sit on the chair
- Students look at the monitor
- Students hold the mouse
- From Level 1 to 8:
- Students listen to Instructions (the researcher holds student's hand, and shows directions in learning)
- Repeating Instructions if required
- Students take Turn
- Student finish learning, and leave (this is when students become tired and refuse to learn)

Context Analysis

Since this application is prepared to draw autistic children's attention, therefore, this analysis is basically emphasized on the physical environment rather than the social and organizational environment (Benyon et al., 2005). The physical environment for teaching must be a quiet class, so that autistic children could focus attention, and listen to the lessons, and there is nothing to make them fear, because autistic children are resistant to change.

Technology Analysis

Four important elements are specified in the Technology Analysis as follows (Benyon et al., 2005):

- **Input:** The autistic students must be able to choose whether they prefer to use the Apple computer or the iPad. The system should contain a touch screen feature to assist the autistic children with weak hands, or a mouse is provided for the ones who prefer using the Apple laptop.
- **Output:** The options should be specified. The system needs to say when the task is completed. A sound must be provided as the system response to the correct answers.
- **Communication:** The communications between the system and the autistic children must be simple and easy.
- **Content:** The system must help autistic children with learning Fasih method (Daud, 2012).

Usability Specifications

Usability Specifications involves the required specifications, from the usability aspect, for the autistic children. Usability specifications divide into two categories of performance measures and preference measure (Bevan & Macleod, 1994). Performance measures are obtained throughout observing how the autistic children complete their task while interacting with the

application and preference measures are user's opinion about the system (Seffah, Donyaee, Kline, & Padda, 2006). Since autistic children could not express their opinion about the system, their response towards the system, or their teacher's opinion could be noted.

For the performance measures the following must be considered (Seffah et al., 2006): Learnability which is the system should be easy for the autistic children to learn, Efficiency which is autistic children must be able to complete their task from one level to another level to reach their goal, and effectiveness which is the system should be simple and clear, and provide easily access for the autistic children. For the preference measures the following must be considered (Seffah et al., 2006); Memorability which is the system should be easy for the autistic children to learn and remember the structure, and Helpful which is the system should be found helpful in teaching Quran to autistic children.

User Interface Requirements

To identify the user interface requirements, the researchers needed to go through the literature review. Reference to the literature review is done to identify how to manage split attention among autistic children using Computer Based Intervention. It could be concluded from the literature review that in order to manage split attention among autistic children, there should be design issues considered for them in designing the application. In addition to the design issues, teaching issues should be incorporated while the teaching process takes place. In the following section, the selected points chosen from the literature review to be considered in managing autistic children split attention in learning are demonstrated in two sections of Teaching Issues, and Design Issues:

Design Issues

The selected design issues summarized from reviewing other researchers' studies are noted as follows:

- **Structuring Information in a Clear Format:** the information should be structured clearly to make the autistic children focus attention, and emphasize on the most relevant information, since autistic children are resistant to change (Wetherby & Prizant, 2000). Moreover, Sweller et al. (2011) mentioned that there should be a clear relation among the information sources provided for the learners. Pociask and Morrison (2008) stated that there should be a great control through the presented information to avoid split attention and redundancy.
- **Using Color Coding Technique:** Kalyuga et al. (1999) declared using colors to direct learners' attention, and reduce the visual amount of search required. They insisted although this technique is helpful to manage split attention in computer based intervention, but manageable amount of colors must be used. Also, Wetherby and Prizant (2000) mentioned to incorporate colors to emphasize on autistic children paying attention.
- **Using Segment-Number Strategy:** Chandler and Sweller (1991) noted that using segment-number strategy presents stronger effect on the learner. Sweller et al. (2011) identified the reason as having smaller information chunks; it is easier for the memory to hold. They also insisted on managing numbers in design in order to avoid complexity.
- **Using Visual Supports:** Wetherby and Prizant (2000) pointed on using visual aids for autistic children in relation to the student's level of comprehension. Visual supports could be presented from simple form to complex and concrete to abstract, such as graphic symbols, pictures, photographs, drawing and written language. Tabbers et al. (2000) noted that using visual cues is an effective strategy to reduce the visual search for learners. Besides, Wetherby and Prizant (2000) declared that incorporating visual materials emphasizes paying attention, comprehending, and using language in play mode.
- **Providing Reinforcements and Rewards:** Wetherby and Prizant (2000) mentioned that reinforcements and rewards must be provided in order to motivate the autistic children.
- **Breaking down the Tasks:** Wetherby and Prizant (2000) insisted on breaking down the instructions into small steps, and teaching in sequence, due to autistic children's split

attention problems. Designers should also consider the child's age, and plan tasks at an appropriate level of difficulty. In addition, the fact that autistic children require more time to respond should be taken into account.

Therefore, it could be concluded that the information provided for autistic children must be clear, and structured properly to make them focus attention, and emphasize the most relevant information. Besides, manageable amount of colors could be used to direct autistic children's attention, and reduce the visual amount of search required. Since autistic children need to be taught in sequence, and step by step, incorporating numbers could have a strong effect on them. Furthermore, autistic children require rewards and reinforcements to motivate them. The tasks designed for autistic children must consider their age, and level of difficulty. Visual materials emphasize autistic children paying attention, comprehending, and using language in play mode.

Teaching Issues

The selected teaching issues summarized from reviewing other researchers' studies are as follows:

- **Giving Instructions to Learners:** Sweller et al. (2011) mention that instructions should be given to the learners while using the computer in order to learn manipulating different parts of the computer. This method was found effective to draw the learners' attention, thus, it is chosen as a teaching method to make autistic children more focused on learning.
- **Giving Precise Information on the Tasks:** Wetherby and Prizant (2000) insisted on giving the autistic children precise information, and positive praise about what they did right in their learning. This motivates the children to proceed if they know they are doing right while interacting with the application.
- **Providing Choices to Choose:** Wetherby and Prizant (2000) noted that providing opportunities for choosing which practice the autistic children prefer is helpful in their learning, and does not frustrate them.
- **Breaking down the Tasks:** It was insisted by Wetherby and Prizant (2000) to break down the instructions into small steps, and teach in sequence, due to autistic children's split attention problems. In addition, the fact that autistic children require more time to respond should be taken into account.
- **Providing Examples:** Wetherby and Prizant (2000) pointed out that using specific examples could give abstract ideas, and encourage conceptual thinking of the autistic children while learning. Therefore, it could be concluded that autistic children required to be given instructions in teaching, and the instructions must be told step by step, and in sequence. Giving the autistic child's precise information and positive praise about what they did right in their learning motivates them. As a part of giving instructions, examples would be provided for the autistic children to teach them how to use the application.

Additional User Interface Requirements

Besides the design issues, and teaching issues, other important elements are required to be considered in the user interface design for the autistic children, according to their identified characteristics in the User Analysis, that are as below:

- The interface should provide aesthetically pleasing presentation to attract the autistic students, and draw their attention.
- The font size needs to be in big or medium size, and not too small, so that autistic children are attracted, and could see the words properly.
- The tasks which an autistic child is required to undertake in the system should be simple and easy to perform, and does not make them feel tired and sleepy.
- This system should be easy to learn for the autistic students, and they should be able to understand how to use the system.

Design and Implementation

After presenting the user interface requirements, the next step is the system design and implementation. The system design is divided into three parts of conceptual design, low fidelity design, and high fidelity design.

Intervention Study

In the Intervention study, the researchers intervened, and evaluated the application with the autistic children. The objective of the Intervention study was to teach autistic children Fasih method using the computer, and measure the effect of using the application on autistic children’s split attention. More to the point, the objectives of the evaluation are specified as follows:

- To assess the effectiveness of using the considered design elements in the application to manage split attention among autistic children.
- To assess the effectiveness of incorporating teaching elements with the considered design elements in the application to manage split attention among autistic children.

Evaluation Participants

Thirteen autistic children from the Autistic Research Lab at the National University of Malaysia (Universiti Kebangsaan Malaysia, UKM) participated in this study. The participating students were from 5 to 18 years old, including Asperger, Mild, Hyper, and Severe autistic kids. One of the thirteen participants was a girl, and the others were boys. Hayes et al. (2010) mentioned that autism is likely to be diagnosed five times more in boys than girls. Thus, it could be understood that autism is likely to occur more in boys in comparison to girls, and the percentage is more in boys. In this study 8% of the participants were girls, and 92% were boys. Figure 1 shows each student’s age. The horizontal axis shows the student’s age according to the sequence of participating in the test. The average age of students participating in the test is nearly 9 years old:

$$\frac{\sum \text{Student's Age}}{13} = 9.15$$

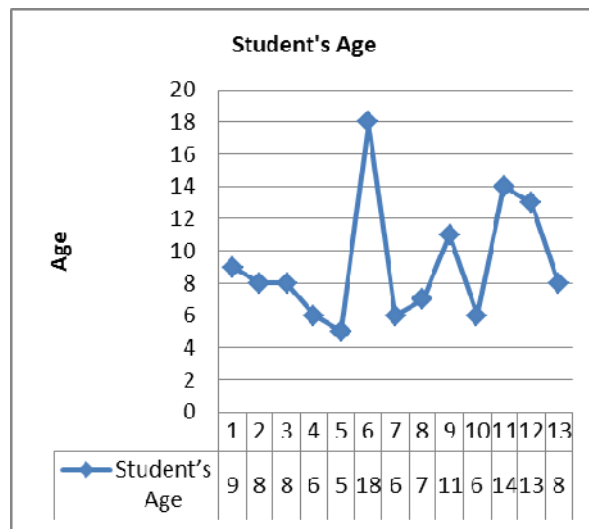


Figure1. Student’s age

The students participating in the evaluation were elementary school students, and could speak and understand Malay, and English language. Besides, most of them know how to use the computer.

Evaluation Method

In order to evaluate the application, experimental method is used. The main purpose of conducting experimental evaluation is assessing the effectiveness of using the considered design elements, incorporated with the teaching elements in the application, to manage split

attention among autistic children. For this purpose, two phases of the study are performed in this evaluation; one using paper-based method, and another is computer based, using the application among the autistic children. A comparison is performed on the gathered data to identify whether the application has effect on autistic children's attention, since the same autistic children participated in both paper-based, and computer method.

Evaluation Materials

In this section, a brief literature review on how to measure the effectiveness of a system is done. Many methods and strategies have been used in Human Computer Interaction (HCI) to evaluate the system effectiveness. Frøkjær, Hertzum, and Hornbæk (2000) define effectiveness as the completeness and accuracy of achieving certain goals by users. Error rates and quality of solution are considered as indicators of effectiveness. Coltekin, Heil, Garlandini, and Fabrikant (2009) mention that effectiveness relates to identifying whether or not the user could successfully complete a task. Kurniawan (2001) emphasized the importance of measuring task completion time which relates to the impact if the information achieved later than it should. Zhu and Meyers-Levy (2007) indicated evaluating the effectiveness of the intended users and task goal is based on the task goal achieving and task completion time which comes under the principles of efficiency. For this reason, according to Kurniawan (2001) task analysis is done to break down the necessary steps required to reach the end target.

User satisfaction is another metric to identify the system's ease of use which falls under the aspect of effectiveness (Kurniawan, 2001). National Institute of Standards and Technology (Fenves, Standards, & Technology, 2001) define satisfaction as the positive attitudes towards using the product and freedom from discomfort. In addition, attitude rating scales could be used to measure user satisfaction level (Frøkjær et al., 2000). Hence, Frøkjær, et al. (2000) declared user satisfaction level as an important aspect of usability. Therefore, reviewing what other researchers said, it could be concluded that in order to evaluate the effectiveness of a system in HCI, the following measurements materials should be included:

- **User Task Completion:** Being able to complete the tasks is an important factor to be considered for the autistic children. Completing a level to another level could be measured for the autistic students to identify whether students could achieve an acceptable level using the application in comparison with the paper based teaching method. Being able to complete the tasks indicates that autistic children could be able to focus their attention on learning and finish one level to another.
- **User Task Completion Time:** Considering this application was developed to draw the autistic children's attention, and make them focus on learning the Fakih method, thus, it could not be denied that task completion time is measured for them, because the application aims at teaching with high quality, and teaching speed is not much important. Additionally, since autistic children have different speed of learning, and also some students are fast in interacting with computers and some are slow, and their task completion time could not be compared with each other. For that reason, task completion time could not be chosen as a suitable measurement metric to evaluate the effectiveness of the system on the autistic children.
- **User Error Rates and Quality of Solution:** Because the autistic children had different background of using computers or iPad, and the students might be experienced, or inexperienced, the number of errors, or quality of the solutions which is the right and wrong answers would be counted, and compared for them. One of the objectives of this application is to help autistic children learn, and focus attention, not to count their correct and wrong answers in the test.
- **User Task Analysis and Achieving Certain Goals:** Task analysis is done to break down the necessary steps required to reach the end target, and to identify whether the user could achieve certain goals. Using task analysis is helpful for the autistic children, since they require being told what to do in sequence, and finally identifying whether they could achieve certain goals. In this research, with the objective of teaching Fakih method, task analysis could be applied to identify whether the autistic children were able to be given instructions, if

yes until which level they could learn, or to identify whether the autistic children were able to take turns, if yes until which level they could take turns. All the results of the computer based, and paper based test must be documented, and compared. In addition, this study aimed at identifying how many times (frequency) autistic children required help in learning which is how many times (frequency) they needed to be taught the instructions.

- **User Satisfaction Level:** User satisfaction is defined as the positive attitudes towards using the system, in which attitude rating scales could be used to measure the user's satisfaction level. Since the autistic children are unable to fill a questionnaire to indicate their satisfaction, the children satisfaction rate is measured by their positive attitude and response towards using the system. The positive attitude is considered as the response to the reward sound saying excellent, and providing cup cake for them. Showing a positive attitude toward the application indicates that autistic children could be able to focus their attention on learning.

According to the National Institute of Standards and Technology (Fenves et al., 2001), from the information given to the user, being able to finish the tasks accurately, in a timely manner is considered as the main importance of effectiveness. Hence, it could be mentioned that in order to identify system effectiveness, time is a significant metric required for inclusion. Because this application was developed with the objective of drawing autistic children's attention, and avoiding split attention, their focus time is measured to identify whether this application was effective on their attention or not. To sum up, the chosen measurement metrics are as follows:

- **User Total Time and Focus Time** which considers the total time and first sight focus time of autistic students.
- **User Task Completion** which considers the autistic student's level of achievement.
- **User Task Analysis** which identifies how many times (frequency) instructions were given to each autistic student. In addition, how many times (frequency) autistic students took Turn in learning is identified.
- **User Satisfaction Level** which is considered as the autistic student's response towards rewards.

Analysis and Result

Comparing the data gathered from the children's interaction with the application, and without the application using traditional teaching methods reveals the following results:

Result 1

The gathered data shows that all of the autistic children were able to focus on learning the instructions in Baseline (with the ratio of 13:13), and Intervention test (with the ratio of 13:13). This means that all autistic children were able to focus their attention on giving Instructions to them. But, the results in students taking turn were different. Figure 2 illustrates and compares students who took turns, and who did not take turns in the Baseline, and Intervention study. To chart number 1, the blue color refers to students who took turns in the Baseline test, and the red color relates to the students who did not take turns in the Baseline test. To chart number 2, the blue color refers to students who took turns in the Intervention taste, and the red color relates to the students who did not take turns in the Intervention test.

In the Baseline study, a ratio of three to thirteen of the students (3:13) were able to take turns. In the Interventions study, a ratio of six to thirteen of them (6:13) had the ability to take turns. Theis improvement in the ratio is considerable to point out that the more autistic students were able to take turns, and to interact with their own, and without any guides. Thus, in the computer Intervention Study more students were able to focus their attention on learning. (See Figure 2)

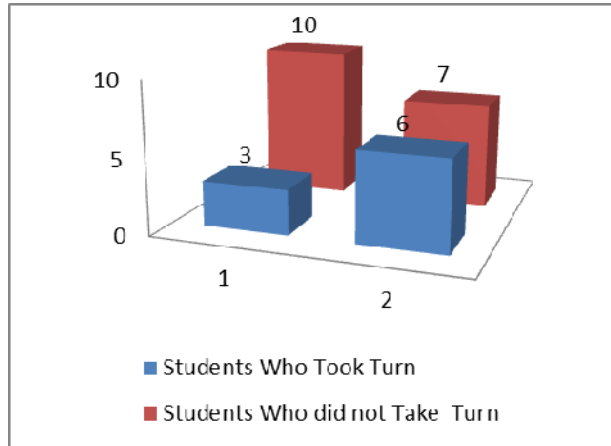


Figure 2. Student's taking turn

Result 2

From the data gathered it could be concluded that all of the participants were able to be given instructions (with the ratio of 13:13). Comparing the times (frequency) instruction were given to students in the Baseline, and Intervention study indicates that most autistic students were able to sit, focus their attention, and listen to instructions more in the Intervention test in comparison to the Baseline test. Figure 3 shows that this improvement had been seen in eleven out of thirteen students (with the ratio of 11:13). The two others who were given instructions once; one had motor skills problems, and the other felt sleepy in teaching him the instructions to learn the practice, and he wanted to do it on his own. Therefore, he took turns, and was able to focus attention, and interact with the application.

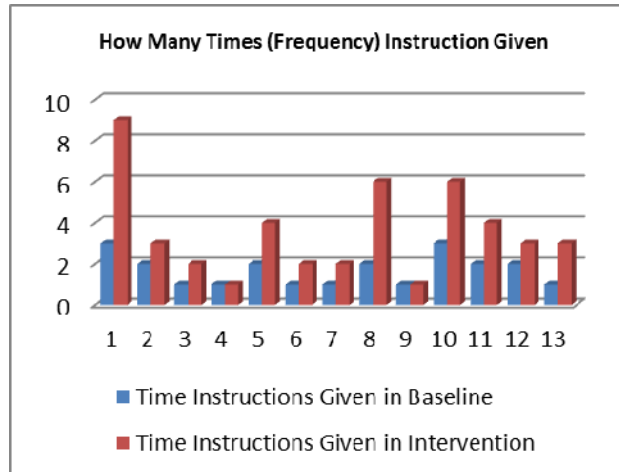


Figure 3. The times (frequency) instruction given

Result 3

Figure 4 shows the student's level in giving instructions, for both Baseline, and Intervention study. Analyzing the student's level from Figure 4, it could be concluded that the majority of the students (with the ratio of 8:13) achieved an acceptable level in the Intervention test which is higher than level 2 in the learning process, or even if they were at level 1, according to Figure 4, they were able to learn more than once, and the teaching process could be continued for them (5:13). Comparing the student's level in Baseline, and Intervention study, most of the students improved their level of learning while interacting with the application. This shows that they were able to spend more time, and focus their attention on learning.

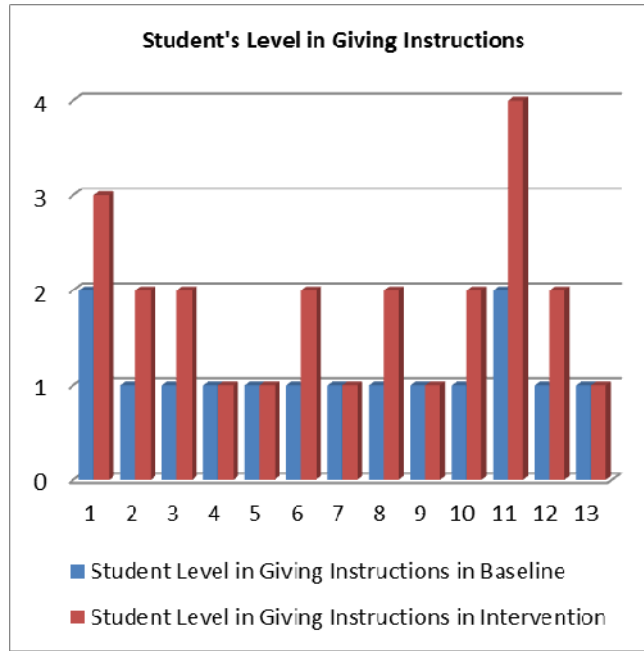


Figure4. Student’s level in giving instructions

Result 4

Figure 2 showed that three students took turns in Baseline test, and six students took turns in the Intervention test. The three students participating in both Baseline and Intervention study are compared. Figure 5 illustrates the compares of student’s Turn. This figure indicates that there was an improvement in the times (frequency) students took turns while interacting with the application. This illustrates that more students were able to focus their attention on the Intervention study.

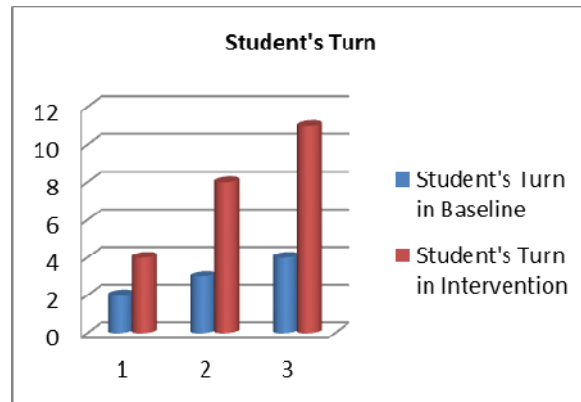


Figure 5. Comparison of student’s turn

Result 5

Figure 6 compares the student’s Total Time in the Baseline, and Intervention study. Analyzing the results indicates that there is a great improvement on all student’s Total Time in the Intervention stage, in comparison with the Baseline stage (with the ratio of 13:13). This reveals that students could more focus attention, and spend more time on interacting with the computer rather than learning by paper.

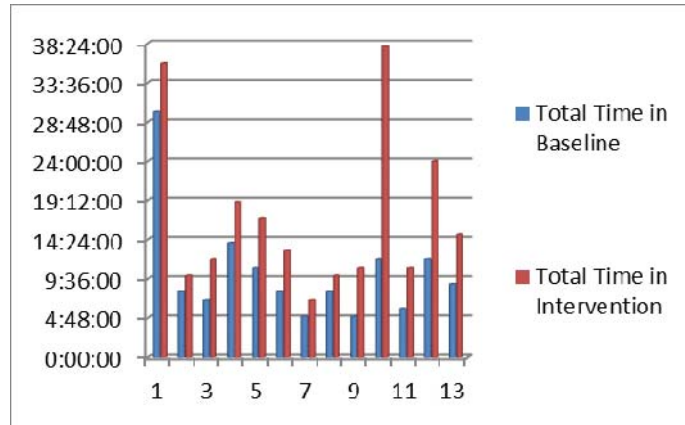


Figure 6. Total time

Result 6

Figure 7 shows and compares the student’s first sight focus in the Baseline, and Intervention study. The first sight focus starts from the time children start learning, by the time they refuse to learn, or they are attracted by their friends, or something else. Comparing the results of Baseline, and Intervention test indicates that the majority of students improved their first sight focus in their learning process, and could put more focused attention on learning (with the ratio of 11:13). The two others who could not focus much on learning were student number 9, and 12. The problem with student number 9 was that she had motor skill problems, shaking problems, and she did not have the power to hold the mouse. Student number 12 was very sensitive towards the sounds, and the sounds made him scared. This fear did not permit him focus, though, he was responsive to the rewards, and start clapping when receiving them.

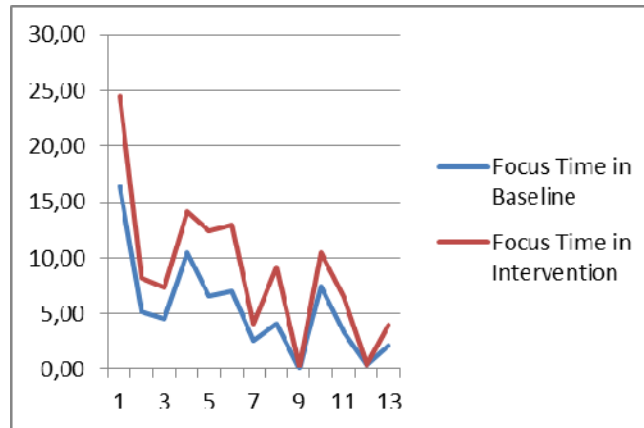


Figure7. Focus time

Result 7

Results show that a ratio of eight to thirteen students (8:13) were responsive to the rewards, and rewards motivated them. This ratio indicates that most students responded when hearing the excellent sound. Although student number 12 could not talk at all, and used sign language, the reward sound saying excellent made him clap for himself. Other students start laughing, looked happy, or started clapping and showing emotion upon hearing the reward sound.

DISCUSSIONS ON THE RESULTS OF THE EFFECTIVENESS TEST

The arisen results of the effectiveness test are discussed in the following sections:

Discussions on the Arisen Result of the Student’s Total Time, and Focus Time

Comparing the evaluation results indicates that there is a great improvement in all student’s Total Time in the Intervention stage, in comparison with the Baseline stage (see Figure 6).

This means students could sit longer, and focus their attention, and listen in the learning class while interacting with the application. Thus, it reveals that students spend more time on interacting with the computer rather than learning by paper. In addition, comparing the results of Baseline and Intervention test indicates that most students improved their first sight focus on their learning process (see Figure 7). Therefore it could be concluded that using the application will have a significant effect on the Student's Total Time, and Focus Time, and makes autistic children focus their attention more on learning.

Discussions on the Results Arising from the Student's Task Completion

Student's task completion time for the autistic children is considered as completing a level to another level in order to identify whether students could achieve an acceptable level using the application in comparison with the paper based teaching method. According to the results to the student's level, it could be concluded that most of the students achieved an acceptable level in the Intervention test which is higher than level 2 in the learning process, or even if they were at level 1, they were able to learn more than once, and the teaching process could be continued for them (see Figure 4). Thus, it could be concluded that most of the students improved their level of learning while interacting with the application in comparison with using paper. Additionally, it could be concluded that using the application makes autistic children focus more attention on learning, and this focusing attention allows them to improve their learning level and be able to finish one level to another.

Discussions on the Result Arising from the Student's Task Analysis

Task analysis was done to identify whether the autistic children were able to be given instructions, if yes until which level they could learn, or to identify whether the autistic children were able to take turns, if yes until which level they could take turns. Wetherby and Prizant (2000) insisted on breaking down the instructions into small steps, and teaching in sequence, due to autistic children's split attention problems. Comparing the times (frequency) instruction given to students in the Baseline, and Intervention study indicates that most students were able to sit, focus attention, and listen to instructions more, and improvements had been reported while interacting with the application (see Figure 3).

In the Baseline study, only a ratio of three to thirteen students (3:13) were able to take turns, and in the Interventions study, 6:13 of them had the ability to take turns (see Figure 2). Comparing the ratio of the results of Baseline and Intervention study shows an improvement in students taking Turn in the test which is a considerable ratio to point that more autistic students were able to focus attention, take Turn, and to interact with their own, without any guide, while using the computer. Comparing the results of the three students who took turns in the Baseline and Intervention study showed there was an improvement in the times (frequency) students took turns while interacting with the application.

Discussions on the Results Arising from the Student's Satisfaction Level

The autistic children satisfaction rate is measured by their positive attitude and response towards using the system which is the children's response to the reward sound saying excellent, and providing cup cake for them. Wetherby and Prizant (2000) emphasized providing reinforcements and rewards in order to motivate the autistic children. Results indicate that 8:13 of the students were responsive to the rewards, and rewards motivated them. This ratio is considerable to specify more than half of the students responded when hearing the excellent sound. Other students, start laughing, appeared happy, or started clapping, and showed emotion upon hearing the reward sound.

CONCLUSIONS AND FUTURE ENHANCEMENTS

The study performed by (Bernard-Opitz, et al., 1990; Chen & Bernard-Opitz, 1993; Panyan, 1984; Yamamoto & Miya, 1999) showed that supporting autistic children with computers in a structured and controlled environment, using multilevel interactive functions were found effective on a variety of computer based interventions. More to the point, the results of this research indicate that using computers in a customized design environment were more effective on autistic children rather than papers. The positive effect of using computers among autistic children allows split attention to be reduced. The reason of decreasing autistic children split attention is because of reducing the children's complexity in the interaction with

the teacher (Ramdoss, Mulloy, et al., 2011). Another reason is using computers offers visual information displays which help autistic children, since they are visual learners (Bondy & Frost, 1994; Whalen et al., 2010).

From the results arising, it could be concluded that using the application improves the autistic children's total time of learning, and also improves the student's first sight focus. This indicates that this application was able to draw autistic children's attention in learning, and make them focus attention which was one of the objectives of this study. While interacting with the application, autistic students improved their level of learning in comparison with using paper. As pointed out by Sweller et al. (2011), giving instructions is effective to make learner focus attention. In this research, the times (frequency) Instruction was given to students improved which indicates that most students were able to sit, focus attention, and listen to instructions more when using computers. Besides, results prove that providing examples aimed autistic children to focus attention on learning which was noted by Wetherby and Prizant (2000) since it offers abstract ideas and conceptual thinking to the autistic children while learning.

Improvements in students taking turn show that they were able to focus attention, and interact on their own, without any guide, while using the computer. More than half of the students responded towards the rewards which show their satisfaction with using the application. Autistic children being able to focus attention while interacting with the application reveals that the considered design issues incorporated with the teaching issues helped, and reduced autistic children's split attention, which means using the application could manage autistic children split attention, and makes them focus attention on learning Fasih method.

Although this application assists the autistic children with the objective of facilitating their split attention, there are still some future enhancements required to be considered in order to improve the application, and have more influence on the autistic children. As the first suggestion, providing Arrows for the application which includes specifying what exact vowel sound to be used. The second suggestion is to provide sound for the application that pronounces the Arabic word. Third, highlight the word that has been numbered. Fourth suggestion is to place numbers on the buttons was hard for children to put it in the exact circle. The final suggestion is that in order to make it easier for the autistic children to differentiate the word and sound by specifying each alphabet word, sound and/or syllables.

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