Facilitating Autistic Children's Split Attention in Designing Computer Teaching Instructions

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Abstract: One of the most important difficulties of autistic children in learning is not being able to focus attention on the relevant information. Considering autistic individuals have higher visual abilities in comparing with ordinary people, visual supports are used to enable learning. Intending to offer visual information displays, computers are used among individuals with autism. Previous researches indicated that autistic children could be supported effectively by providing a structured and controlled environment using computer based intervention. Preparing instructions for the autism spectrum requires customizing specific design issues to facilitate their split attention. Moving forward in this paper, it is concluded that in addition to the design issues to be considered for the autistic children, teaching instructions need to be incorporated. This paper aims to present the specified user interface design issues incorporated with the required teaching instructions for the autistic children to facilitate their split attention.
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1. Introduction

According to [1, 2], autism is defined as a complex developmental disability which is the result of a neurological disorder that affects the normal brain functioning and influences the development of social interaction and communication skills. Reference [3] describe the main characteristics of the autistic children disorders as impairment communication which is the earliest symptom shown as the word of [4], delay in language development, using language idiosyncratically and repetitively and not being able to begin or maintain a conversation [3, 5]. Reference [6] 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 [7].

Due to autistic children disabilities, they are having various challenges in their life. One of the most important difficulties of autistic children is learning. According to [3], one of the most important worries of autistic children in learning is not being able to focus and pay attention to the relevant information and cues. This defect prevents autistic children to pay 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. 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 [8, 9].

Many researches had been done to investigate a method for teaching and assisting autistic children learn most effectively [10-15]. Considering autistic individuals have higher visual abilities in comparing with ordinary people [16], visual supports are used to enable learning [17]. Reference [18] 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 structured and controlled setting [11, 19]. Thus, in order to facilitate the autistic individual practice and training in various skills, computers are used [11]. Moreover, another significant concern is how to present the computer instructions to the autistic individuals considering their split attention. In this paper, we will focus on how to facilitate autistic individuals' split attention while using the computer in their learning. Furthermore, the design issues, and teaching instructions that are required to be considered for the autistic children are identified in this study.

For this purpose, first of all, we will present the basic definitions of this paper. Secondly, the split attention is defined, as well as pointing at split attention different categories, and specifying methods to overcome it. Thirdly, the writers point at how to facilitate split attention among the autistic children's. Finally, the identified design issues, and teaching instructions are offered as a result of this research.

2. Computer and Autistic Children

Offering a structured and controlled

environment, using multilevel interactive functions, [20-23] found computers successful as a teaching instrument among autistic children. There are several reasons for selecting computers as a feasible approach in teaching literacy skills to autistic children [24]. First of all, research by [25, 26] indicate that autistic children are visual learners and computers offer visual information displays that is customizable. Secondly, computer 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 [13]. Thirdly, research by [27] shows that autistic children are highly responsive while using computers that could make academic demands. As a final point, computers could be used for a particular student's ability level by selecting the appropriate setting in order to utilize for an individual instruction [13].

References [22, 23] mention that computers are used effectively in teaching different instructional skills to the autistic children. [28] 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 [29] successfully used computer animated tutor including receptive and expressive language activities.

Reference [10] Used computer based intervention systematically in teaching literacy skills such as reading, and sentence construction with the intention of improving the autistic children vocal and non-vocal communications. Reading and writing skills were enhanced for the autistic children interacting with computers as stated in the study of [30]. [31] 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.

Reference [22] emphasize that using computer based intervention among autistic children in classrooms with high amount 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 the children with autism allows performing programs that deliver many necessary functions and instructions [22]. Research by [20] indicated that autistic children had presented more correct answers, and improved behavior skills after using computer based intervention rather than using traditional instruction.

Reference [32] 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 the acquisition of many skills such as language and speech, reading, math, auditory processing and life skills [32]. [33] 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 which is in a controlled and structured environment [11].

3. The Split Attention

Split attention takes place when learners are required to divide their attention between at least two sources of information [8]. Intending maximum learning and understanding occurs, all disparate sources of information must be integrated as far as possible [8]. 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 [8]. 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 effect happens when an instructional strategy based on integrated materials resulting in improved learning outcome rather than splitting sources of information [8]. Replacing integrated source of information instead of using multiple sources in which learners need to divide their attention results in a more effective learning environment [8]. This integration is done using multimedia materials [34], both text component and picture component of information to enable learning and understanding. By integrating multiple information sources physically, and the unnecessary interacting elements, this search could be reduced, and learning would occur [8].

3.1. Split Attention Various Categories

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 [8]. If isolated multiple information sources are unlearnable and unintelligible, split attention effect must be facilitated among learners [8]. 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.

The initial research done [35] [36] [37, 38]

showed that facilitating learns split attention was used in the field of sciences and mathematics such as geometry and algebra. The study by [38] in the geometry area demonstrated that if the work example was presented in a split source format, it has no improvements, but if it had integrated structure it has a significant advantage in learning. Also [38] found that in using diagram sources it is more effective to provide explanations note at the closest point of reference. They insisted that the notes must be embedded into the diagram which limits time and memory process of searching the required references rather than writing below the diagrams.

Furthermore, reference [38] extended their research into the numerical control programming domain in which students were obligated to write programs to control the industrial machinery. [39] attained split attention effect in the geography field in which is reliant upon diagrams, text and tables. Their survey results demonstrated that the integrated approach helped learner better recall the detailed items in comparing with the split format. Chandler and [40] successfully integrated diagrams of electrical circuits with text to give information on the electrical wire installation to the learners.

Reference [41] proved that in learning hydraulic braking system, integrating the picture with the text placed near each other has got a much better outcome on the learners. Further on, [42] prepared a booklet on lightning works in two forms of integrated strategy and split attention strategy to be tested on grouped students. The group that received integrated strategy booklet in which the illustrations were placed next to the text, had done superior on tasks in comparison to the separate format. In order to teach students the lightening formation Moreno and [43] used computer based animations in separated and integrated format as [42]. In the integrated form where the text was placed close to the appropriate diagram students performed better on transfer tasks.

Later research on split attention effect was extended to other domains of learning. Rose and [44] found that using two integrated sources of information is more effective in teaching a decision aid for calculating tax liabilities and instructions on calculating tax for the undergraduate accountancy students. [44] replicated the same result in a similar research. The split attention effect was found in the domain of economic materials tested on undergraduate economics students by [45]. [46] noticed the split attention effect in learning complex orthopedic physical therapy skills. Research by [47] used the effect to explain very detailed instructions to teach the structure and physiological processes in the human kidneys.

Reviewing what other researchers have done

demonstrates that integrating essential sources of information has a great advantage on learners' understanding. Presenting information in split source form requires learners to search for connection with the information sources if they could not understand in isolation [8]. By integrating disparate sources of information, search 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 [8]. Reference [38] integrated two sources of text information and numerical control programming in order to investigate on two groups of students. The study outcome proved that the integrated group achieved higher scores, and involve less time searching for the information correspondence and the references.

Reference [48] explored the split attention effect for more than two information sources in the domain of learning Chinese as a second language. [48] offered three flash cards to the learners simultaneously in which containing the Chinese character, the English translation, and the relevant phonic. His investment indicated that when the English and phonic cards were presented close to the Chinese character, better learning and pronunciation was obtained instead of placing the cards far apart each other [48].

Reference [49] studied the effectiveness of learning Chinese as a second language by using phonics in vertical and horizontal format. They compared the results of the study from the high school students when learning Chinese vocabulary in learning vertical and horizontal layout. The end result showed that learning Chinese in vertical format has a significant advantage since the phonics is placed exactly under the related character as illustrated in Figure 1 [49].
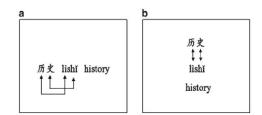

Figure 1. Presentation of (a) Vertical Format, (b) Horizontal Format [8]

3.2. 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 [8]. Reference [8] mentioned Learners must read the information and learn how to

manipulate different parts of a computer, such as the mouse, or typing a specific text to run the particular application. [38] tested the learners who wanted to learn about a Computer Aided Design (CAD) or Computer Aided Manufacture (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 to 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 rather than students practicing with the equipment physically.

Recent research done by [8] indicates that students could effectively learn how to use computer programs by giving all the instructions in an integrated or single module. [50] expressed that there is no difference between the presentation of instructions whether it is paper based or on the screen manually. 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 [50]. The physically integrated strategy was found superior in comparison with the split source formatting where the screen based instructions were not integrated.

According to [38][50], the split attention effect takes place using high element interactively materials. As it is mentioned by [8] because of having lots of tasks to be done in the 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. [8] 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.

3.3. Methods to Overcome Split Attention

Research done by [8] indicates that the 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 [51] 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, [52] found that using visual cueing is an effective strategy to reduce the visual search by isolating the text with colors.

Reference [53] 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 it is mentioned by [38], 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 the segment - number strategy had stronger effect on the learner rather than the fully integration form. As noted by [8], the reason of segment-number format effectiveness is having smaller information chunks which are easier for the memory to hold.

Reference [54] remarked 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 [54] suggested that by inserting the text at the relevant position in the diagram but hidden form unless the learner click 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, the solutions time was quicker, and there were more user control.

To support the effectiveness of the pop-up method, [55] 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 more superior comparing with the integrated format. [56] 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 be appeared in a separate screen immediately since the learners click on the specific part of the map, and still could facilitate more learning.

4. Facilitating the Autistic Children's Split Attention

In facilitating the split attention there should be a control over the conditions of applicability from the required information sources. As stated by [8],

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.

Reference [8] pointed 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 facilitating the split attention, intending highest learning and understanding takes place for learners, all different information sources must be integrated as far as possible [8]. Reference [8] stated that the split attention effect provides the significant instructional design principles to help the designers how to include the information that must be considered simultaneously.

Therefore, in facilitating split attention within the information sources the 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 [8]. In addition, learners working memory should be reduced and they should not search to find a relation within the information sources [8]. In brief, in split attention management, there should be a great control through the presented information to avoid split attention and redundancy [46].

According to [3], 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 to pay 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 [3]. In addition autistic children might show a short attention span. Consequently, autistic child's difficulties have a significant effect on their learning and language development.

As stated by [3], because of autistic children disabilities, instructional activities and the information provided for teaching these students must be structured in a format that is clear, makes them focus their attention, and emphasizes on the most relevant information. For this objective, using visual supports as a teaching approach for autistic children is suggested by [3]. Visual aids have been widely successful for the autistic children and help them to cope with their difficulties in learning, thinking, understanding and communications. As mentioned by [3], one of the advantages of using visual aids is enabling autistic children to focus 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 the children with difficulty in language processing and 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 indicated by [3], 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 autistic 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 [3]. Giving the autistic children precise information and positive praise about what they did right in their learning could be motivating. Providing opportunities for choices to choose which practice they prefer might be helpful in autistic 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 children age, provide reinforcements and rewards, 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 autistic to break complex tasks down into subtasks and reinforce in sequence and small. Incorporating colors for the children with the autistic might be helpful in representing the emotional context.

5. Discussions

Identifying the user interface requirements, the researchers had to go through the literature review to specify how to facilitate split attention between autistic children using Computers.

Categorizing the review work of different authors on how to facilitate autistic children split attention, the following table (see Table 1) is raised:

Table 1. Review of Methods to facilitate Split Attention among autistic children

Author	Issue
[8]	Giving instructions to the learners to use a computer in order to learn how to manipulate different parts of computer
[51]	Directing learners attention by using color coding technique to reduce the visual amount of the required search
[8]	Managing numbers, and the relevant symbol or text to fewer interacting elements.
[52]	Using visual cues to reduce the visual search
[40]	Using segment-number strategy
[8]	Using segment-number strategy
[54]	Placing picture and text close the pop-up display
[8]	Split attention effect provides the significant instructional design principles in which the structure should contain a clear relation among the information sources
[46]	great control through the presented information
[3] (in structuring information)	Information provided for teaching these students must be structured in a format that is clear, makes them focus their attention, and emphasizes on the most relevant information.
[51]	Use manageable amount of colors
[3] (in giving instructions)	Using visual supports as a teaching approach
	Giving the autistic children precise information and positive praise about what they did right in their learning
	Providing opportunities for choices to choose which practice they prefer
	Break down the instructions in to small steps due to their split attention problems.
	Autistic children require more time to respond
[3] (in designing instructions)	Consider the children age
	Provide reinforcements and rewards
	Plan tasks at an appropriate level of difficulty
	Using specific examples
	Task analysis to break complex tasks down in to subtasks and reinforce in sequence and small
	Incorporating colors, visual materials, and using language in play mode.

It could be concluded from the literature review that in order to facilitate split attention between autistic children, there should be design issues considered for them in designing the system.

In addition to the design issues, teaching instructions should be incorporated while the teaching process takes place. Bellow the selected points chosen from the other researcher's opinion to be considered in facilitating autistic children split attention in learning is demonstrated in two sections of Teaching Instructions, and Design Issues:

5.1. Design Issues

The selected design issues taken from reviewing other researchers study are noted as follows:

Structuring Information in a Clear Format: Reference [3] revealed that the information should be structured clear to make the autistic children focus attention, and emphasizes on the most relevant information, since autistic child's resistance to change. Moreover, Reference [3] mentioned that there should be a clear relation between the information sources provided to the learners. [46] stated that there should be a great control through the presented information to avoid split attention and redundancy.

Using Color Coding Technique: Reference [51] declared using colors to direct learners' attention, and reduce the visual amount of search required. They insisted although this technique is helpful to facilitate split attention in computer based intervention, but manageable amount of colors must be used. Also, Reference [3] mentioned to incorporate colors to emphasize on autistic children paying attention.

Using Segment-Number Strategy: Reference [3] noted that using segment-number strategy presents a stronger effect on the learner. Reference [8] 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: Reference [3] 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. Reference [3] noted that using visual cues is an effective strategy to reduce the visual search for learners. Besides, Reference [3] declared that incorporating visual materials emphasizes on paying attention, comprehending, and using language in play mode.

Providing Reinforcements and Rewards: Reference [3] mentioned that reinforcements and rewards should be provided in order to motivate the autistic children.

Breaking down the Tasks: Reference [3] insisted on breaking down the instructions into small

steps, and teaching in sequence, due to autistic children split attention problems.

Therefore, it could be concluded that the information provided for autistic children must be clear, and structured properly to make them focus attention, and emphasizes on the most relevant information. Besides, manageable amount of colors could be used to direct autistic child'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 on autistic children paying attention, comprehending, and using language in play mode.

5.2. Teaching Instructions

The selected teaching instructions taken from reviewing other researchers study are pointed as follows:

Giving Instructions to Learners: Reference [3] mentioned 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 learner attention, thus, it is chosen as a teaching method to make autistic children more focus on learning.

Giving Precise Information on the Tasks: Reference [3] 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 system.

Providing Choices to Choose: Reference [3] noted that providing opportunities for choices to choose which practice the autistic children prefer is helpful in their learning, and does not frustrate them.

Breaking down the Tasks: It was insisted by [3] to break down the instructions into small steps, and teach in sequence, due to autistic children split attention problems.

Providing Examples: Reference [3] pointed that using specific examples could give abstract ideas, and conceptual thinking to 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 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 system.

5.3. Usability Specifications

Besides the design issues, and teaching instructions, other important elements are required to be considered in the user interface design for the autistic children. Usability Specifications involves the required specifications from the usability aspect, for the autistic children. Usability specifications divide into two categories of performance measurement, and preference measurement [57]. Performance measurement is obtained throughout observing how the autistic children complete their task while interacting with the system, and preference measurement is the user's opinion about the system [58]. 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 measurement the following must be considered [3]; 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 accessible for the autistic children. On the other hand, for the preference measurement the following must be considered [3]; 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 autistic children.

6. Conclusions

This paper presents the user interface design specification among autism spectrum disorders, due to their difficulties in paying attention, language development, and handling complex information [3]. The significant point of this research is to motivate and help the autistic children have better learning, and understanding. Another concern is to reduce autism challenges in their life by using visual supports since autism are visual learners. Due to autistic spectrum difficulties, managing and facilitating their split attention while interacting with the computer is one of the objectives of this study. Finally, to identify the design issues incorporating with the teaching instructions that are required to be considered for the autistic children. The identified issues aims to prepare teaching instructions for the autistic children in learning to make them focus attention, and avoid splitting attention using computer based intervention. The future enhancement of this paper is testing the effectiveness of the prepared system on the autistic children split attention, and improve the lacks of user interface design specification for them.

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