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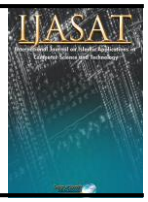

# Autism Content Management Learning System for Children with Autism

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## Abstract

The popularity of autism in children in the world is estimated as one per 62 children, higher level reported in some countries. These children experience significant problems with the development of social behavioral and verbal and non-verbal communication skills. The skills impairment level varies from an individual to another and that made teaching autistics a challenge for caregivers such as teacher and relatives. Hence, there are quite a number of frameworks of software learning systems which focus on gaining the children's attention using representational visual illustration as a learning method instead of the textual form. However, majority of these tools are lacking the personalization ability to suite everyone in the spectrum as well as the ability to perform new production of learning materials by the caregivers. This paper proposing Autism Content Management Learning System (ACMLS) Framework to assist caregivers to produce, design and fine-tune or customize the learning materials appropriately so that the system interface and the materials are suitable for every individual in the spectrum according to each child personal profile aiming to make learning attractive and to contribute in improving their social, communication and behavioral skills and nonetheless, their attention level to the delivered educational topics.

***Keywords*:** children with autism, caregiver, personalized learning, intervention.

## 1. Introduction

The term 'Autism Spectrum Disorder' (ASD) refers to a cluster of developmental disorder that present from birth or very early in development, with usually life-long effects on essential human behaviours such as social interaction, communication, imagination, and relationships with others (National Research Council, 2001). ASD has been characterized as a spectrum of difficulties in these areas that vary in combination and severity, between and within individuals (Charman, 2002).

On the other hand, interest in assistive technology and educational games has increased in the last decade and the moving towards the gaming usage as playing a key role in the educating children with autism (Konstantinidis, Luneski, Frantzidis, Costas, & Bamidis, 2009) in schools and homes (Manero, Torrente, Serrano, Martínez-Ortiz, & Fernández-Manjón, 2015; Zhang & Kaufman, 2016). The use of technology in educational interventions for children with autism, such as computer-aided learning, has been shown to benefit areas such as literacy skills (Tjus, Heimann, & Nelson, 2001; Williams, Wright, Callaghan, & Coughlan, 2002), facial recognition abilities (Tanaka et al., 2010) and social skills (Mitchell, Parsons, & Leonard, 2007; Piper, O'Brien, Morris, & Winograd, 2006). Pennington (2010) also suggests that computer-

aided instruction could be beneficial in other academic areas such as mathematics and science (Shute & Zapata- Rivera, 2007).
This paper presents the ACMLS prototype design and evaluation aiming to validate the usability, effectiveness and efficiency of the proposed ACMLS prototype and the potential of releasing it for the public use.

## 2. ACMLS Framework Design

The ACMLS framework design adopts four main components (Figure 1) which are: (1) Design component: which covers the visual design, design principles and the mental model of the children with autism. (2) Technology component: which covers the assistive technology tools and the architecture of the ACMLS system. (3) Education component: Which covers the learning objectives, styles, strategies, methods and the cognitive model. (4) Participants component: which covers the main participants who're playing a role in the ACMLS framework such as: caregivers and children with autism.

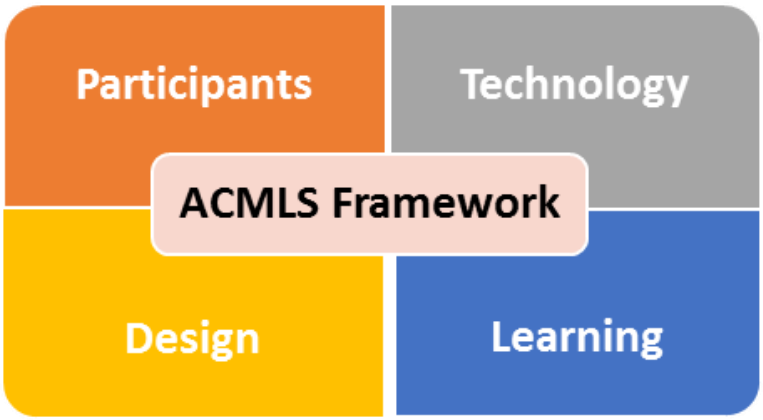


Figure 1: ACMLS Conceptual Model

Designing an assistive technology educational environment for children with autism has to be based on the following design principles:

1. Predictable, structured and controlled environment with consistent structure with a clear start and finish (Davis, Dautenhahn, Powell, & Nehaniv, 2010; Grynszpan, Martin, & Nadel, 2008; Leach, 2010), and discourage inappropriate repetition so children don't become fixated on (Davis et al., 2010).
2. Children with autism are very systematic (Baron- Cohen, 2009) compared to Typical children and they prefer A highly structured environment to explore (Davis et al., 2010; Leach, 2010; Van Rijn & Stappers, 2008).
3. Avatar or on-screen character can be particularly helpful (Higgins & Boone, 1996), as they frequently can need guidance on where to focus (Davis et al., 2010).
4. Direct feedback on actions helps children to feel in control (Van Rijn & Stappers, 2008). Although it should not distract from the task (Leach, 2010) and feedback on any failures should be non-critical and provide alternative strategies for achieving success with the next attempt (Davis et al., 2010).

## 3. ACMLS Prototype Evaluation

Figure 2: ACMLS main screen

Figure 3: A child using ACMLS


Figure 4: Quranic quiz application

Figure 2 shows the list of tutorials implemented in the system whereby Figure 3 shows an autistic child using the ACMLS prototype on a touchscreen tablet. Figure 4 shows a question and a multiple choice answers; the child has to recite the verse (Question) and complete the blank space. Since one answer is correct between the four answers. When the child clicks on any answer, an immediate feedback will be prompted to indicate if the answer is correct with applaud sound or wrong with a wrong answer sound, the correct answer will be colored with green if correct and red if wrong answer. Moreover, a sixty seconds is allocated for each question and points system is counting when questions answered correctly. At the end of the quiz the child will be shown the total score. Caregivers such as teachers and parents should be able to see the children progress at school and/or at home.

## 4. ACMLS Prototype Evaluation

The ACMLS framework evaluation is done through three evaluation phases: usability heuristics evaluation, experts' feedback and Neurosky Mindset feedback respectively in order to judge the framework quality. The results of the framework evaluation indicated that the proposed ACMLS framework is an effective and efficient tool to be used rather than the traditional methods in the autism centers or schools.

### 4.1 Evaluation Participants

Ten participants, four girls and six boys were contributed to evaluate the ACMLS prototype, these participants are diagnosed with mild autism who exhibit low attention level from "PRF autism center" the Islamic center for children with special needs as well as "Autism Café" Centre in Kuala Lumpur, Malaysia. The participating children age range between 4 and 14 years old, they're familiar with computers and smart devices such as Ipad and android devices.

However they're from observations like to touch and point to the computer screen instead of using the mouse and keyboard to express their answers or reactions.

### 4.2 Study Objectives

Based on the ACMLS framework design; the ACMLS prototype is developed aiming to increase the attention level for children with autism in learning and cope with the educational materials given to them in schools, rehabilitation center or at home by producing a content management system for learning children with autism which accessible by teachers or parents. As mentioned earlier this chapter will present different evaluation methods so the evaluation objectives per study are as follows:

1. First evaluation phase is aimed to evaluate the model of the ACMLS framework is effective and efficient to the end users by collecting the experts feedback and evaluate their satisfaction to the proposed ACMLS prototype as a new learning medium for children with autism to be used at schools, rehabilitation center and at home. And to evaluate the experts understanding in terms of their roles and tasks carried out by the system.
2. Second evaluation phase is aimed to evaluate the usability of the general and specific tools in the ACMLS using heuristic evaluation (Nielsen, 1994).
3. Third evaluation phase is aimed to evaluate the attention & meditation levels throughout the Mindset headset readings by placing the headset on the participant's forehead.

### 4.3 Evaluation Procedures

The ten participants were observed during the traditional learning style (baseline) as well as the ACMLS learning style within a total period of 9 weeks (2 sessions per week and 20 minutes for each session) in two center. The first 4 weeks were mainly to observe the children as well as the teacher's traditional methods used to educate the children, data collection in the first center PRF autism center for six participants and from the second center (Autism Café) for four participants.

The following five weeks are maintained to train the teachers/parents on how to use the system and feed the system with educational materials either in the autism center or at home. The ten participants had the chance to use the ACMLS system at home as well as at both center as part of their activities.

The last week was utilized to conduct the Mindset evaluation while using the ACMLS system in order to collect the data related to the Mindset evaluation phase. Furthermore, the questionnaires and the interviews were conducted in order to fulfil second, third and fourth evaluation phases.

### 4.4 Phase 1: Experts Feedback

The experts' feedback has also contributed in the ACMLS framework evaluation, it has been done throughout structured interviews whereby the teachers as well as the parents answer a predefined questions in order to evaluate the effectiveness, efficiency and quality of ACMLS system as a learning medium for children with autism at autism center and at home. Moreover, the Likert survey is used too to collect experts' feedback after using the ACMLS system.

#### 4.4.1 Structured Interviews

Structured interviews require the use of a set of standardized questions which are created in advance. Structured interviews keep the order and phrasing of the questions consistent across

interviews to ensure consistency in the data being collected. The questions are prepared as the following:

***Question 1:*** What is your opinion using the ACMLS system as a new learning medium for children with autism?

***Question 2:*** What is your opinion of the ACMLS system user interface design?

***Question 3:*** Have you noticed any progress on the child/children after using the ACMLS system compared to the traditional approach?

***Question 4:*** What would you suggest to add into the ACMLS system in order to make it more efficient?

### 4.4.2 Structured Interviews Results and Analysis

This section presents the experts' interview results and there answers to each question in order to assess the evaluation of the ACMLS framework effectiveness as a new learning tool.

Experts introduced their answers to first question: children with autism are not mentally retarded, they only have issues in information processing and they have a low ability in understanding complex information, teacher can't ask long-form questions such as: "Do you want to eat cake?", rather they show them a picture of the cake and the reaction of the child helps teachers to understand the answer whether by saying a "yes", "no", shaking head, clapping hands or facial expression so teachers should understand their ability in information processing. ACMLS system assesses in simplifying the information or instructions which are given in a simple manner which makes a successful new learning medium for children with autism.

Experts responded to second question that the user interface design is appropriate and suites the children with autism in terms of the simplified interface and the short path to access the materials. This helps children with autism in accessing the materials easily and in a time manner which adds efficiency to the system.

Based on the experts' answers to the third question, they mentioned that the ACMLS system helps the majority of children who participated in the study to improve their social, cognitive awareness, communication and behavioral skills progress throughout learning material presentation.

Last but not least, three experts are generally satisfied using the ACMLS system as a platform for children with autism learning when they answers the last question, while one expert suggested to add more avatars or animation in the rewarding feedback section.

### 4.4.3 Likert Survey of Experts' Feedback

Figure 5 presents the experts' feedback using Likert scale of the ACMLS system, Majority of the participated exerts have described that children with autism are showing anxiety and antisocialism prior to the usage of ACMLS system. However, some of experts found that the use of the ACMLS system as a new medium for learning is useful, the rest are still believing in the traditional approach. Hence children showing interests using ACMLS system, therefore, there is a potential of having a mixed approach of both ACMLS framework usage and the traditional approach as well. Experts agreed on the values of this study due to what they witnessed during the intervention sessions.

## 4.5 Phase 2: Usability Heuristics Evaluation

In order to evaluate the system usability, an informal walkthrough method was used (Nielsen, 1994) in order to conduct a system heuristics evaluation, this method is adapted to the specific context of teacher and learners.

In the usability test, the teachers practiced their designated role in the ACMLS system in order to evaluate the screen design and user interface in the teacher portal. The focus in this stage was to evaluate the teacher portal functionalities. Then the usability tests are performed on the learning sessions with children focusing on the children navigations and interactions with the system.

We faced a problem during the evaluation process which is the users often verbalize whatever comes to their minds. However, they are not able to formulate their thinking process and apply it into the ACMLS system. The teachers suggested to pair a verbal with none verbal children during the evaluation process aiming verbalize, collaborate and interact with the system.

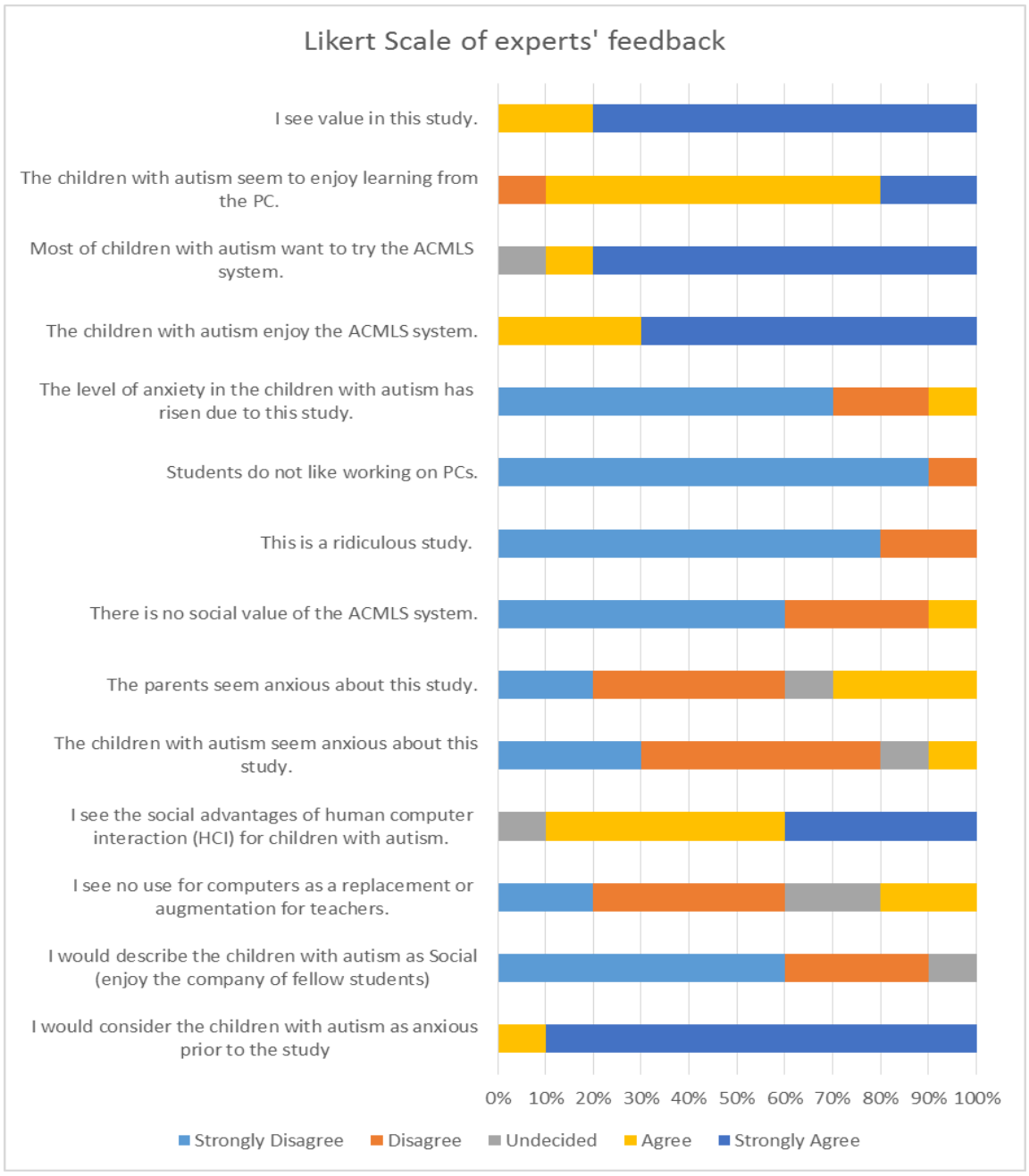


Figure 5: Likert scale presentation of the experts' feedback

The tests were conducted during the last intervention session, and children in pairs are given the access to the ACMLS system and the teacher was playing the supporter role during this stage. Children were observed to be motivated and keep verbalizing. The teachers review was children interaction is working and they are navigating seamlessly throughout the given activity. The small tasks given to them is manageable and suite their skills and stamina. They're attracted to the system colors and animations, moreover they show difficulty in using the system initially, however, they adapted to the system the more they use it to keep learning in a better way. In addition to that, the audio and animation during the learning process and after each quiz question was useful and kept the students engaged during the learning process.

### 4.5.1 Usability Heuristics Evaluation Results and Analysis

Heuristics evaluation survey was distributed to teachers and parents shows the following results:

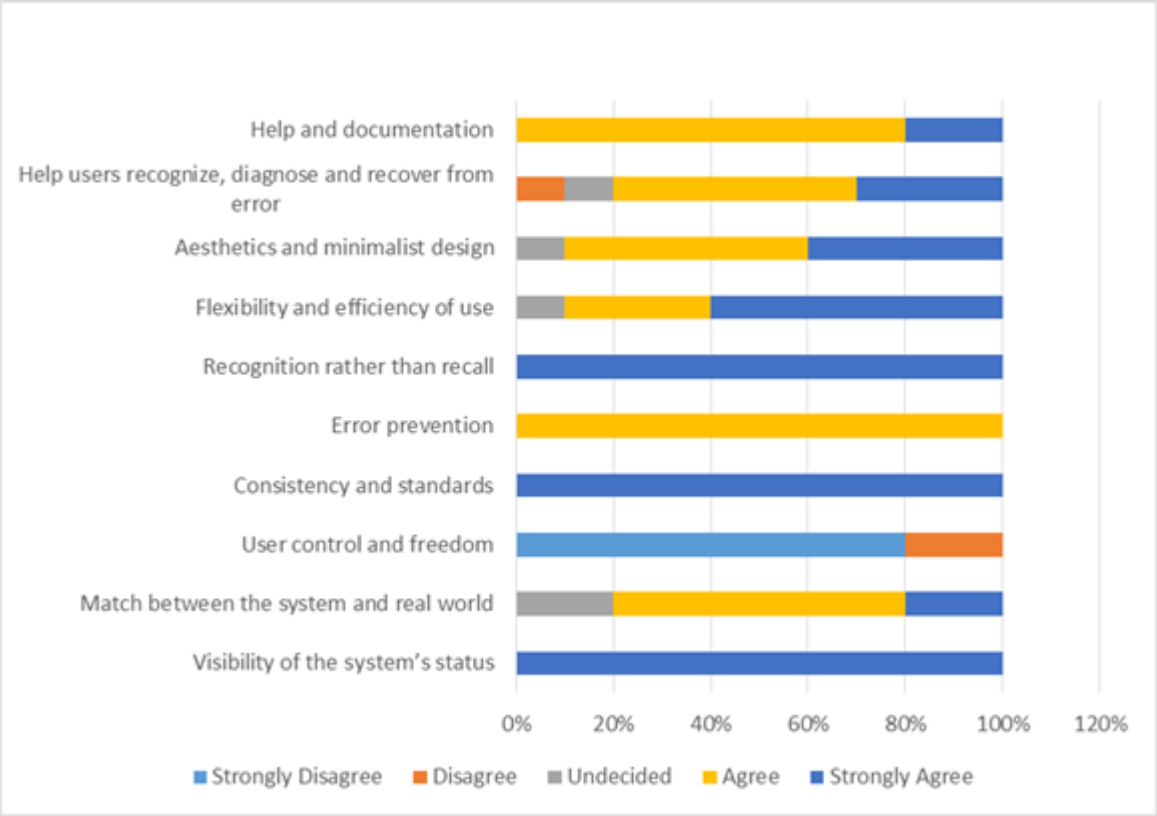


Figure 6: Heuristics evaluation of the ACMLS system

Figure 6 shows the results of the heuristics evaluation of the ACMLS system and an explanation for each usability point score as below:

***Visibility of the system's status***. Evaluators agreed on the visibility and clarity of the system status and feedbacks are given within a reasonable timescale. One evaluator has mentioned that:

*"The system timer is visible and counting down for each question in the quiz section which requires the children to mark their answers before the time ends".*

While another evaluator added:

*"The system icons are visually visible and expressive".*

***Match between the system and real world***. 40% of the evaluators are neutral about the system matching the real world while 20% of the evaluators don't agree, and the reason they mentioned is:

*"It requires the system admin, teacher or parents to feed the system with a close to real world scenarios and relevant materials so it can full fill this point".*

Another evaluator added:

*"Information should be presented in a logical and specific order and this the teacher's role to do" and another evaluator added "Information should be presented in a familiar means to the user including language".*

***User control and freedom***. All evaluators agreed that the user control and freedom of use is satisfactory and the system provides a convenient controls such as the touch screen feature if the screen is compatible.

One evaluator commented that:

*"The system should have an 'emergency exit' which easy to find so the children can exit the system without having go through many steps"*. The same evaluator added *"It would be good if a 'return to prior screen or Go Back button' is added to the system"*.

***Consistency and standards***. All evaluators agreed on the formatting of the words and actions are consistent so that the children don't get confused and it always means the same thing to the user.

***Error prevention***. The system doesn't show error messages to the children and all evaluators are pleased with this feature, one of the evaluators mentioned that:

*"Error prevention is much better than showing clear error messages to the children"*.

***Recognition rather than recall***. ACMLS system has simple design, clear and easy instructions to follow. Hence actions, options, and objects are visible to the children, therefore, it doesn't add any load on their memory. In the quiz section the answers have a shuffle feature whereby children should remember the correct answers rather than to remember the answer place from one screen to the next.

***Flexibility and efficiency of use***. All evaluators have agreed that by using the system often, the learning process for children can be accelerated and improve the system efficiency and effectiveness in learning. One evaluator has mentioned that:

*"Using short learning topics or tasks can make learning process much faster than loading children with many information at once".*

While another evaluator said:

*"The system isn't loaded with many links or buttons and that makes so specific".*

***Aesthetics and minimalist design***. 40% of the evaluators are satisfied with the system simple design and another 40% of them are neutral while the other 20% would like more features to be added to the system design such as: extra buttons, menus to list extra learning sections and search feature. The satisfied evaluators debated these comments by

*"The targeted environment for the ACMLS system are children with autism, therefore, system design has to be very light and not complicated and that's to keep the children focused on learning not distracted by unrequired features at least in the beginning".*

They added

*"The more data in dialogue the more it confuses the overall visibility of the learning objectives for the children".*

***Help users recognize, diagnose and recover from error***. The system is guaranteed error free especially for the children, whereby system administrator, teachers or parents might experience certain types of errors due to a slow network connection or server down. Hence those are the major errors that could happen, thus, the system shows those errors to the end users. One evaluator mentioned that:

*"Having a customized error messages would be a user friendly as well as a guide of how to recover from certain errors in case it occurs".*

***Help and documentation.*** All evaluators agreed on the ease of use of the system, it took the teachers and parents a session of 10-15 minutes for each one of them to learn how to use the system in terms of adding new learning materials and customizing or personalizing the children profiles.

Most of the evaluators agreed on having a help page for the system admin, teachers and parents will be very useful.

### 4.6 Phase 3: Neurosky Mindset Evaluation

The last evaluation phase is done using the Mindset headset aiming to gauge the meditation and attention levels during the traditional and intervention sessions. Five children were present to this evaluation phase for a duration of five minutes for the traditional session (baseline) and another five minutes for the intervention session using the ACMLS system.

The Mindset is placed on the targeted child head making sure the forehead Mindset sensor is making a contact with the child's forehead in order to establish the Bluetooth connection and start transmitting the brain waves to the system for the duration of five minutes for the baseline and the intervention sessions.

#### 4.6.1 Mindset Results and Analysis

Table 1: Meditation and attention scores at baseline and intervention

| No. | | Baseline Meditation Score | Intervention Meditation Score | Baseline Attention Score | Intervention Attention Score |
|---|---|---|---|---|---|
| **1** | Child A | 32% | 36% | 48% | 59% |
| **2** | Child B | 31% | 38% | 53% | 60% |
| **3** | Child C | 32% | 37% | 52% | 59% |
| **4** | Child D | 31% | 32% | 50% | 62% |
| **5** | Child E | 32% | 41% | 50% | 65% |

The average meditation and attention levels in the duration of five minutes was extracted and presented in the table above. The meditation and attention levels for traditional and intervention

sessions show that ACMLS system can assess in increasing the meditation and attention levels, so that children are focused and paying more attention using ACMLS system compared to traditional learning methods.

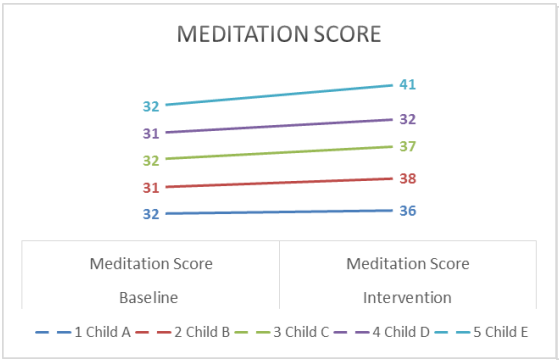


Figure 7: Meditation score

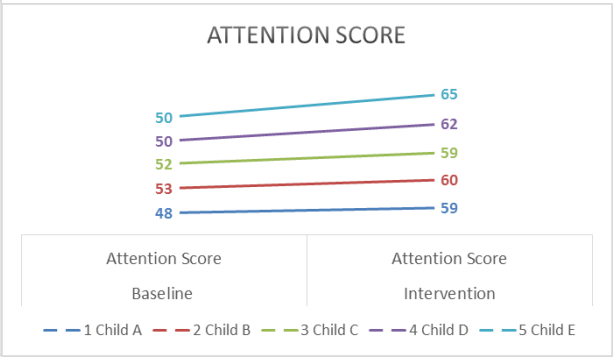


Figure 8: Attention score

Figures 7 and 8 are present the meditation and attention scores for the five present children for the duration of five minutes in traditional and ACMLS system sessions.

## 5. Conclusion

This paper showed the results, analysis and findings of the main three evaluation stages which are suggested to evaluate the ACMLS framework. Initially and before conducting the evaluation, the participants' demographics data and their background were identified. The evaluation objectives were set and explained.

The first evaluation phase was the experts' feedback stage which was carried out by structured interviews and survey, the Likert survey graph showed that the ACMLS framework an effective method for both teachers and parents to use and feed the system with educational materials and better approach to be used by children in order to effectively enhance their skills. The second evaluation phase was the usability evaluation stage which aims to evaluate the system interfaces and their complaint to the usability heuristics set by (Nielsen, 1994). The evaluation was done through a questionnaire and the results analysis showed a satisfactory results.

The third evaluation phase was the Neurosky Mindset evaluation stage, the data was collected from the Mindset device by extraction of the children's brain waves during the traditional learning and while using the ACMLS system, the results showed that children are paying more attention and meditation levels compared to the traditional learning approach.

Finally, throughout the three stages of ACMLS framework evaluation, the conclusion is the framework proved its usability, effectiveness and efficiency to influence children with autism to improve their skills and enhance their daily life activities performance.

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