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# Educational Software as Assistive Technologies for Children with Autism Spectrum Disorder

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## Abstract

Nowadays, some developing countries are experiencing many problems regarding children with Autism Spectrum Disorder, including Indonesia. Autism Spectrum Disorder is a childhood-onset developmental disorder of the immature brain, which impairs social communication and social interactions in addition to persistent restricted, repetitive patterns of behavior or interests. Children with Autism Spectrum Disorder need special treatments, such as therapy by professional and certified therapists. However, there are limitations to the number of therapists and the therapists have difficulty using therapeutic tools that require extra preparation time, also there are only a few applications that help therapists to carry out the therapy for Autism Spectrum Disorder children, especially applications that are developed in Indonesian and have complete features. Therefore, in this study, we proposed Squizzy, which is an assistive technology application that specifically designed as educational software for children with Autism Spectrum Disorder and developed in a tablet environment. During the development of Squizzy, we implemented Scrum methodology that will be explained in detail later. Based on the evaluation and discussion that conducted, Squizzy received many positive feedbacks from users, such as it helps therapists and parents to ease their therapy sessions by reducing the inconvenience of the therapeutic tool. Moreover, Squizzy successfully covered the cognitive part of children's therapy.

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## 1. Introduction

The term autism or autistic is taken from a Greek word "autos", which means self. Bleuler then introduced this term to describe self-centered thinking in schizophrenia<sup>1</sup>. Autism Spectrum Disorder (ASD) typically denotes a childhood-onset developmental disorder of the immature brain, which impairs the social communication and social interactions

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in addition to persistent restricted, repetitive patterns of behavior or interests<sup>2</sup>. Publication of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) put ASD under neurodevelopmental disorders<sup>3</sup>. Intellectual disability in ASD is characterized by deficits in general mental abilities such as: problem solving, planning, abstract thinking, judgment, academic learning, and learning from experience. Communication disability in ASD represented by deficits in language, speech, and communication.

According to World Health Organization (WHO), one in 160 children has ASD<sup>4</sup>. Meanwhile, there is no official survey that counts the prevalence of ASD in Indonesia<sup>5</sup>. Dr Rudy Sutadi reported that there are 2 new cases per 1000 population per year and 10 cases per 1000 population since 1997<sup>6</sup>. Indonesia's population is 237.5 million with a population growth rate of 1.14% in 2010<sup>7</sup>. Therefore, the prevalence of ASD in Indonesia are 2.4 million children with the addition of 500 new cases per year.

Some developing countries still experience many problems in facing the ASD cases<sup>8</sup>, including Indonesia. The government has been seen paying attention to the needs of people with autism by providing autistic service centers in several provinces across the country<sup>9</sup>. Nonetheless, there are still three main problems: the lack of specialist expertise in assessing ASD, the lack of tools for conducting assessments, and the lack of therapists in taking care of ASD patients<sup>10</sup>. The intention to support children with disabilities should be a priority with the focus of removing barriers and providing facilitators, such as technology tools technology tools and service delivery for the children to be able still participating in the community.

Assistive technology (AT) is an umbrella term for any device or system that allows individuals to perform tasks they would otherwise be unable to do or increases the ease and safety with which tasks can be performed<sup>11</sup>. International Standards Organization (ISO) has revised the definition of assistive products for persons with disability into "Any product (including devices, equipment, instruments and software), especially produced or generally available, used by or for persons with disability available, used by or for persons with disability for participation to protect, support, train, measure or substitute for body functions structures and activities, or to prevent impairments, activity limitations or participation restrictions"<sup>12</sup>.

Children with intellectual disability such as ASD requires special education. Another challenging aspect is children with ASD also suffer from communication disorders. Studies have shown that these children often analyze and receive visual information more effectively than auditory information<sup>13</sup>. Individuals with ASD prefer interventions, which involve interacting with technology as it causes them less anxiety than face-to-face or group-based work. Furthermore, AT enables a special systematic approach to learning, which is particularly appropriate for the cognitive profile of individuals with ASD<sup>14</sup>.

Current software technology has potential to become a promising assistive technology for these children. There was also a clear growth in the number of research articles published during the last decade that addressed the issue of technologies for children with autism<sup>15</sup>. Several attempts has been made such as: assistive tools for social interaction<sup>16</sup>, interactive visual supports applications<sup>17</sup>, augmented reality games<sup>18</sup>, story book<sup>19</sup> and learning media<sup>20</sup>. These applications have a similarity, which is successfully encouraging the children to increase their interest to interact towards the environment and other people.

Several studies also observed the potential these assistive technology to supplement the lack of ASD experts and therapists. One of them was robots that interactively interact with child with ASD<sup>21</sup>. Other study utilized a mobile application to assist therapists and teachers in schools in educating child with ASD<sup>22</sup>. The children tend to give more positive response when interacting with the application.

Portable software such as web, mobile, or tablet application indeed developing rapidly in these recent years<sup>23</sup>. They possess the significant advances and are often the cheapest amongst the software technology. Several attempt has been made to use mobile applications to contribute in therapy for children with autism<sup>24,25</sup>. Recent study also evaluated the potential mobile applications as assistive technology in terms of functionality features<sup>26</sup>. They prepared an evaluation matrix based on Dawe research<sup>27</sup>. The result shows that even there are many variation of application, there are still too few that are suitable with the children with the special needs. Only half, even less of the necessary criteria are fulfilled.

Because of the lack amount of software as assistive technology for children with ASD especially in Indonesia, this study presents "Squizzy". Squizzy is an assistive technology application, that specifically designed as an educational software for the children with ASD. Squizzy is developed for the tablet environment, because of its portability

and wide enough screen. The requirement gathering process will be further discussed in chapter 2. The result and discussion are presented in chapter 3.

## 2. Related Work

There were several examples of software as assistive technology in order to increase autism children interest or easiness on their interaction towards the environment and other people. MOSOCO is a mobile application that help students with autism practice social skills in real life situation<sup>16</sup>. Using interactive interface, MOSOCO engage the student to make eye contact, maintain appropriate spatial boundaries, and reply to conversation. MOSOCO also helped them to share their interests with partners, disengage appropriately at the end of an interaction, and identify potential communication partners. Other interactive tools are Mocotos, a mobile visual augmentative communication aid and vSked, a multi-device interactive visual schedule system<sup>17</sup>. Instead using normal oral conversation, student can use the application interface to point out their expression or answer questions by pointing into given choices.

Augmented Reality also introduced as a system aiming to promote open-ended pretend play for young children with autism<sup>18</sup>. The result indicated there was a significant increase in frequency and duration of the children interest compared to a non-computer setup. This results is achieved because of the prominent visual effect of the AR system itself. Meanwhile The GameBook introduce the children with a story that can be read by text or listened by audio<sup>19</sup>. The story involved scenarios and real world situations and engage the children to be involved on the fictional contents by interactin with it's 3D avatar. The proposed design promoted the interaction between the children or the storyteller and their imagination. This also helped the child to identify the correct emotional face for the given scenario in the story. ARDOA is an application that utilizes Flash Card as learning media using Augmented Reality<sup>20</sup>. ARDOA helps Muslim children learned how to do their daily prayer in the form of audio and video animation.

Other studies observed the potential of assistive technology to supplement the lack of ASD experts and therapists. The latest advances in deep learning is used to formulate a personalized machine learning (ML) framework for a robot<sup>21</sup>. The framework used to develop an automatic perception of the children's affective states during robot-assisted autism therapy. The results demonstrate the feasibility of robot perception of affect and engagement in children with autism for the design of future therapy. A mobile application that can be used as a tool that can foster the knowledge and the experiences of preschool children also been explored<sup>22</sup>. The study present that the application helped children who face learning and math problems. Special education in kindergarten obviously demands support of the new technology such as mobile application and it has shown promising and appropriate result.

Mobile application has been favoured recently because of its portability, ease of access, and often the cheapest amongst the other software technology. A study explored how children and young adults with ASD are currently using iPads<sup>®</sup> and applications during their daily activity (learning, playing, and interactions)<sup>24</sup>. There is also a review of iPad and its applications for their efficacy in helping improve a child's communication skills<sup>25</sup>. There are five important point to consider, they are: 1) customization, 2) students's motoric skill 3) the resources and time needed for the intervention, 4) choosing right applications, and 5) device and application cost. Recent study also proved that mobile applications has potential to become assistive technology in terms of functionality features<sup>26</sup>. The study also prepared an evaluation matrix based on other research<sup>27</sup>. According to the matrix, parents and teachers tend to favor the technology to be as simple as possible.

## 3. Research Method

Squizzly is an assistive technology, that specifically designed as an educational software for the children with special needs such as ASD. Our target user is children with the age of 5 to 15 years old. Designing an assistive technology for children with special needs requires a user-centered design that focus on the entire life-cycle of the technology. Starting from the configuration, maintenance, up to upgrade and replacement. Application for children with ASD should not be treated the same as ordinary application. As an assistive technology application designer, extra effort is required to understand and gather input from the various individuals in charge of caregiving the children as each caregiver has their targets and expectations around the assistive technology.

The research method for developing Squizzly is shown in fig. 1. For the requirement gathering, the interviewees come from from Yayasan Cinta Harapan Indonesia (YCHI) Autism Center<sup>28</sup>. YCHI provides help and support to

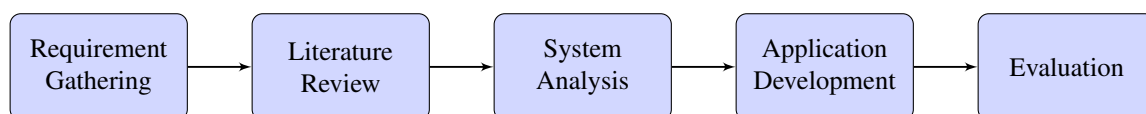


Fig. 1: Research Method of The Study

children with special needs such ASD from fortuneless families without being charged. We interviewed two psychologist, five therapist, and five parents of children with ASD in YCHI. We used an evaluation matrix based on research conducted by Melissa Dawe<sup>27</sup>. Based on Dawe research, parents and teachers tend to favor the assistive technology to be as simple as possible. We try to make Squizzy as simple as possible, yet still maintain its functional purposes. Therefore, we decided there are three key factors to consider when developing Squizzy, they are: 1) portability, 2) ease of use, and 3) usefulness.

### 3.1. Portability

At YCHI, each child is assigned to a therapist. Meanwhile, a therapist can handle two to five children, which is not the optimal number. The therapist uses a therapeutic tool which requires extra preparation time. The therapy mostly done in the clinic. Yet, sometimes the therapist come to the children house and bring all the therapeutic tool. The therapist agree that some activity can be substituted into digital version, which is in the form of a software. The parents also believed that with the help of the application, they can also conduct the therapy session even without a therapist present. This might slightly help reduce the therapist workload and ease the child necessity for therapy session.

Portable software such as web, mobile, or tablet application is developing rapidly in these recent years. We decide to develop Squizzy in the form of tablet application, which is known for its portability. Some parents also recognize that most technology will break or outdated and need to be replaced. Hence, Squizzy does not required the latest tablet technology. Squizzy currently only available for iPad with minimum operating system iOS 10. iPad is chosen because there were other researches that successfully use iPad as learning devices for children with ASD<sup>29 30</sup>.

### 3.2. Ease of Use

In terms of ease of use, parents specifically referring to the need for a very simple interface. The application should have low learning curve. If the application is hard to use in the first time, the children were very unlikely to ever go back to it. Nowadays, most application focus on interactive interaction between multimedia objects (text, images, audio, video, and animation) and the user. While dealing with children with ASD, each interaction should have meaningful purpose, because most of those children lacks focus on finishing certain task. Therapist in YCHI suggest that the application should avoid having too much distractors such as illustrated images. Even the slightest eye-catching event could distract the children focus. Moreover, the children understand the real picture better than the illustration.

Another concern is the language, because most of the children only understand Indonesian. Therefore, we decided to develop Squizzy using only real picture instead of the illustration one and not overly using it. We also choose Indonesian as the language because as currently, to our knowledge, there is not many educational software in Indonesian.

### 3.3. Usefulness

Therapy session conducted usually in the form of 1) inserting wooden blocks with various shape and size into its container, 2) matching and re-ordering cards that shows pictures of day to day activity, 3) matching text and images, 4) arrange simple puzzles. We tried to replicate those type of activity into tablet application.

Each activity has three levels of difficulty, mudah (easy), medium (sedang), dan sulit (hard). There are five questions to be answered for each set of activity. Current question must be answered correctly before proceeding to the next question. Therapist can set the difficulty level, depends on the child condition. Easy level is designed as an introduction

level. The challenge is guaranteed to be success because only the correct answer present in the answer choice. Medium level rises the challenge by showing two answer choices. Hard level gives the most challenge because it provides three answer choices. The application also 'score' the child performance on the challenge and record the time needed to complete it. This scoring system means only as a record to track the child progress. After successfully completing the activity, the children then will be given praise in the form of words or confetti animation.

Two other features are added, such as Perpustakaan (library) and Laporan (Report). Perpustakaan helps the child to get to know new objects and its shapes. While Laporan mostly helps the therapist and parents monitor their child daily therapy session progress.

Scrum method is implemented when developing the application. As for the evaluation, Squizzy is delivered to the therapist and parents whose treating children with ASD in YCHI. There are ten children who will use Squizzy during their therapy session. Especially for therapy session in the children's house, the therapist are not required to bring all the therapeutic tool because most of the activity can be done by using Squizzy. Some parents will also have Squizzy installed in their tablet and experiment the activity by themselves. After several therapy session, we will interview the therapist and parents again to have their feedback regarding the Squizzy.

#### 4. System Overview

Squizzy has six main features, of which four are the features for therapy and the other two are additional supporting features. Each features will be discussed later. At the start of the application, the user is greeted with Squizzy introduction screen as shown in fig. 2.

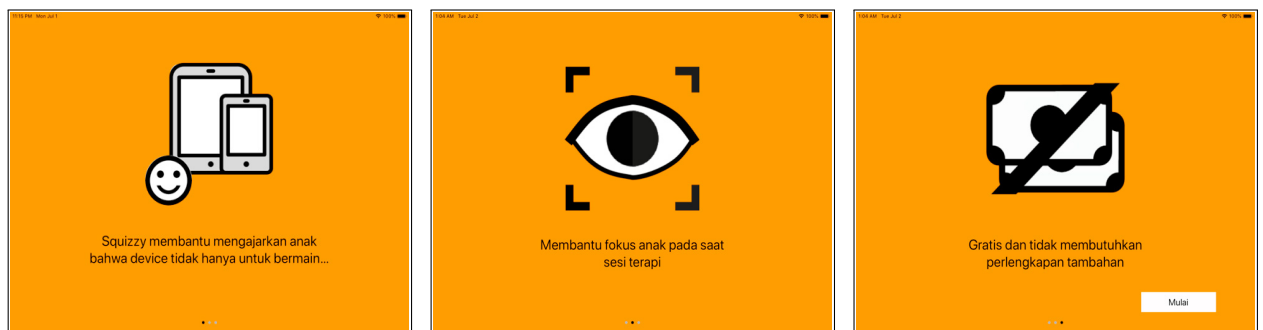


Fig. 2: Squizzy Introduction Screen

Each child progress will be kept separately while using Squizzy. Child name must be filled in first as shown in fig. 3a. After that the application will show the main menu as shown in fig. 3b. From this screen, user can navigate to other menus. Description of each menu will be presented in subchapters below.

##### 4.1. Cocokkan Gambar (Image Matching)

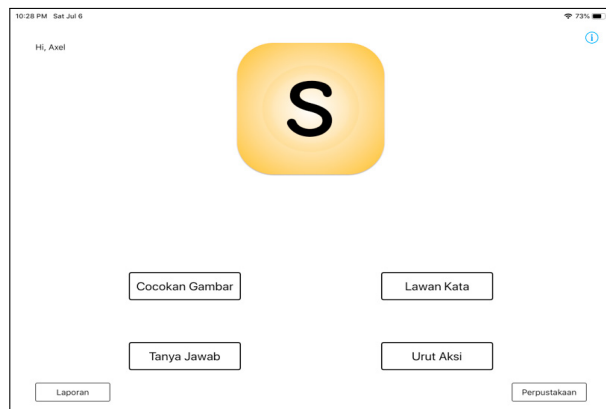
In this activity, the child must match the given pictures with other same pictures from the given choices. fig. 4a shows the screen for choosing the difficulties. Meanwhile figs. 4b to 4d shows the screen for each difficulty: easy, medium, and hard.

##### 4.2. Lawan Kata (Opposite Words)

In this activity, the child must find the opposite word of the given task. After that, the answer must be chosen from the given pictures. fig. 5a shows the screen for choosing the difficulties. Meanwhile figs. 5b to 5d shows the screen for each difficulty: easy, medium, and hard.

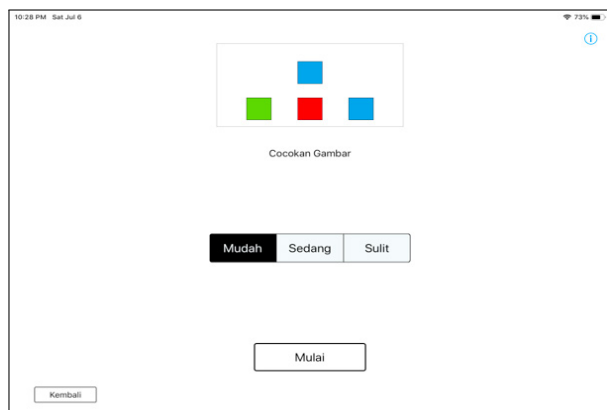


(a) Home Screen of Squizzy



(b) Main Menu of Squizzy

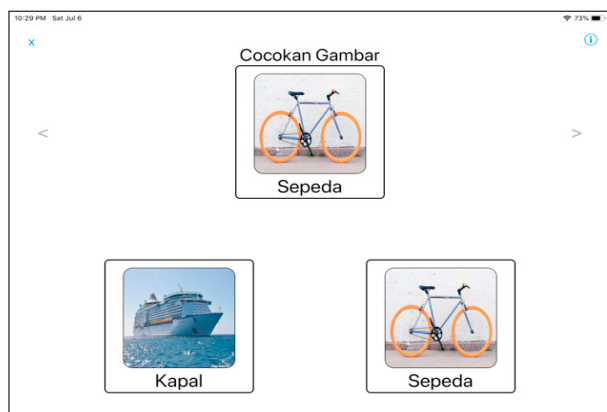
Fig. 3: Squizzy Introduction Screen



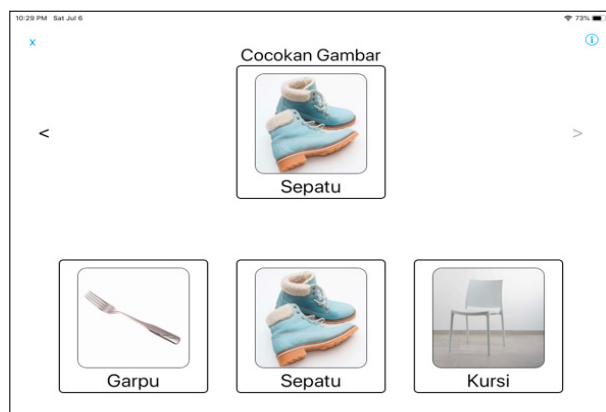
(a) Cocokkan Gambar - Choosing Difficulty



(b) Cocokkan Gambar - Difficulty Easy

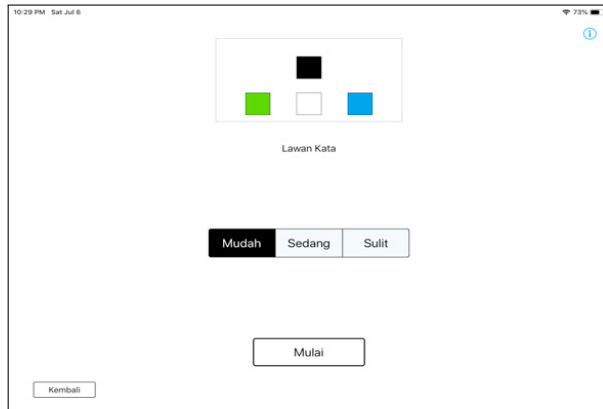
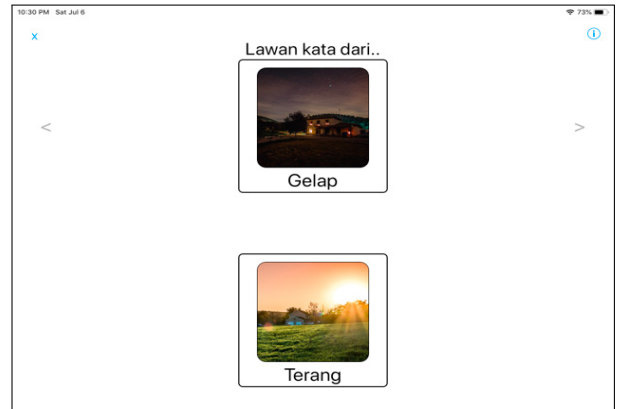


(c) Cocokkan Gambar - Difficulty Medium



(d) Cocokkan Gambar - Difficulty Hard

Fig. 4: Squizzy Cocokkan Gambar (Image Matching) Activity

(a) *Lawan Kata* - Choosing Difficulty(b) *Lawan Kata* - Difficulty Easy(c) *Lawan Kata* - Difficulty Medium(d) *Lawan Kata* - Difficulty HardFig. 5: Sizzly *Lawan Kata* (Opposite Words) Activity

#### 4.3. Tanya Jawab (Simple Question)

In this activity, the child must answer of given question by choosing the appropriate picture. fig. 6a shows the screen for choosing the difficulties. Meanwhile figs. 6b to 6d shows the screen for each difficulty: easy, medium, and hard.

#### 4.4. Urut Aksi (Ordering Action)

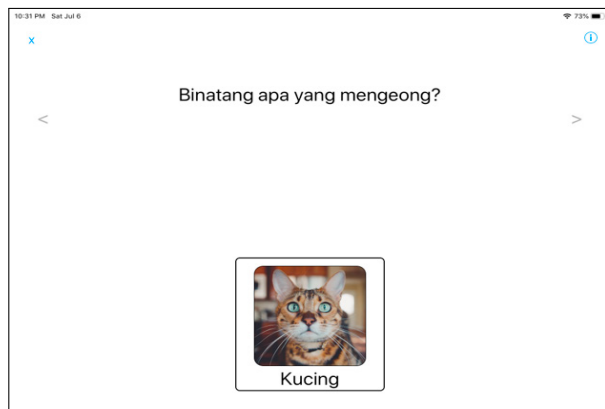
In this activity, the child must order list of items or actions, to accomplish a goal. This activity is special, in which it does not have difficulty level. fig. 7a shows the starting screen of the activity, while fig. 7b shows the activity screen.

#### 4.5. Laporan (Report)

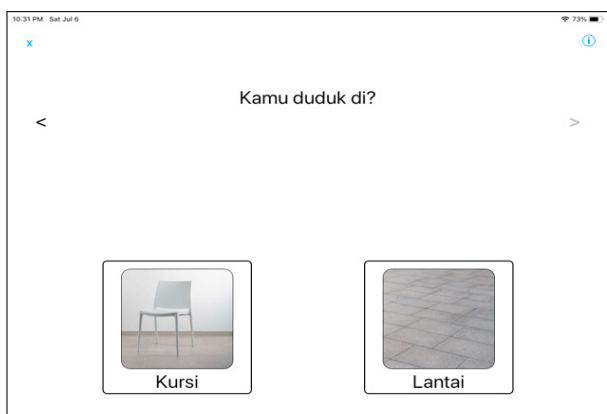
Accessing menu Laporan from the main screen, the user can browse current child history activity as shown in fig. 8a. Information shown are date, type of the activity, difficulty level, score, and activity duration.



(a) *Tanya Jawab* - Choosing Difficulty



(b) *Tanya Jawab* - Difficulty Easy

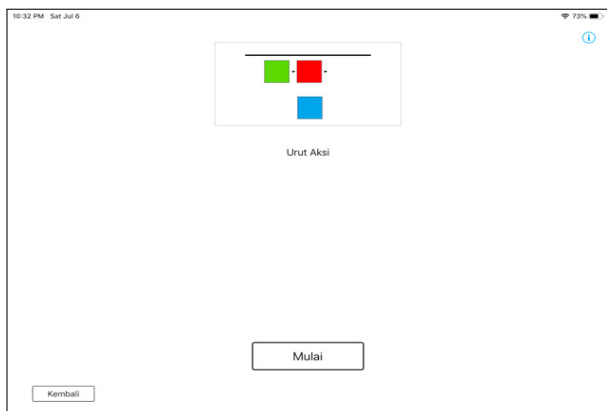


(c) *Tanya Jawab* - Difficulty Medium

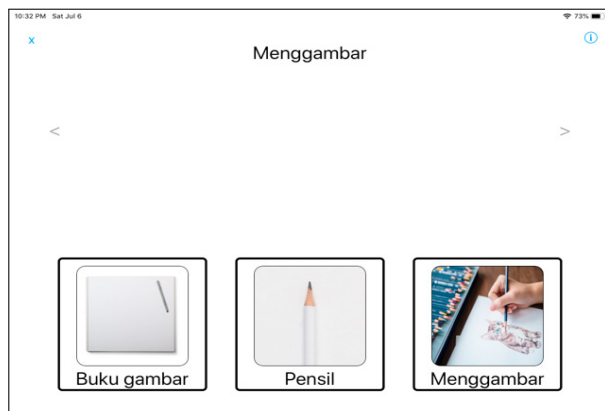


(d) *Tanya Jawab* - Difficulty Hard

Fig. 6: Sizzly *Tanya Jawab* (Opposite Words) Activity



(a) *Urut Aksi* - Initial Screen



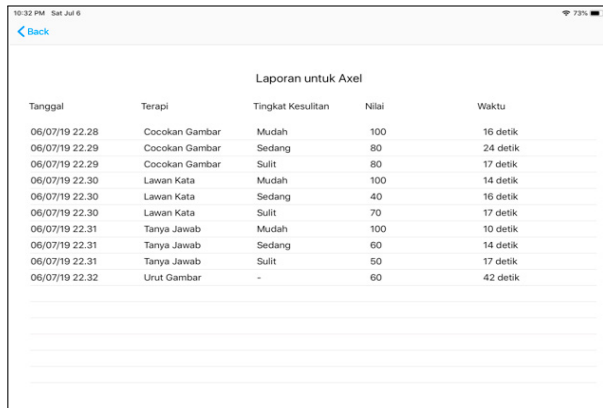
(b) *Urut Aksi*

Fig. 7: Sizzly *Urut Aksi* (Opposite Words) Activity



#### 4.6. Perpustakaan (Library)

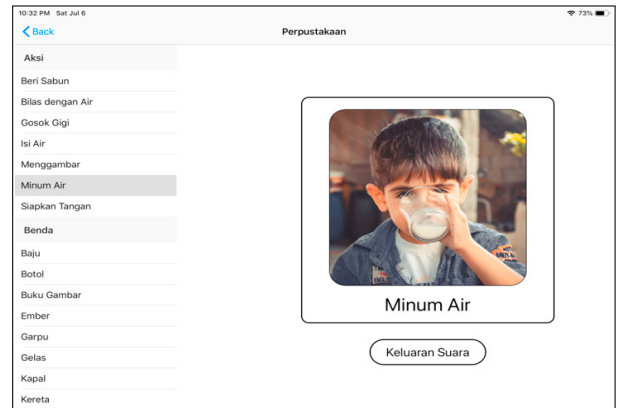
Squizzy library menu contains list of items such as: images of action, objects, animals, emotions, concepts, and food. Children can scroll through list of this items. Clicking on one item will shows the picture. There is also a button to play the audio of the items name. The display of this menu is shown in fig. 8b.



Laporan untuk Axel

Tanggal	Terapi	Tingkat Kesulitan	Nilai	Waktu
06/07/19 22.28	Cocokan Gambar	Mudah	100	16 detik
06/07/19 22.29	Cocokan Gambar	Sedang	80	24 detik
06/07/19 22.29	Cocokan Gambar	Sulit	80	17 detik
06/07/19 22.30	Lawan Kata	Mudah	100	14 detik
06/07/19 22.30	Lawan Kata	Sedang	40	16 detik
06/07/19 22.30	Lawan Kata	Sulit	70	17 detik
06/07/19 22.31	Tanya Jawab	Mudah	100	10 detik
06/07/19 22.31	Tanya Jawab	Sedang	60	14 detik
06/07/19 22.31	Tanya Jawab	Sulit	50	17 detik
06/07/19 22.32	Urut Gambar	-	60	42 detik

(a) Squizzy Laporan Menu



(b) Squizzy Perpustakaan Menu

Fig. 8: Squizzy Laporan (Report) and Perpustakaan (Library) Menu

## 5. Results and Discussion

Squizzy is tested to ten children with ASD who were accompanied by their therapist or parents. The therapist is greatly helped by the presence of Squizzy especially in because of its portability. They are not required to bring all the therapeutic tool because most of the activity can be done by using Squizzy. Even some parents have Squizzy installed in their tablet and can easily do the activity with their children. During every activity, therapist must present to direct the children focus on the activity, not the tablet device itself. The children must be given understanding that Squizzy is not a game, but rather a tool to help them learn.

Another positive feedback received is the simple design of Squizzy, which make it has low learning curve. During the testing, the children quickly learn to use the application because Squizzy only use simple movement, such as click and drag. Knowing that excessive design may distract the children attention, Squizzy prefer simple basic color selection and it is proven to be effective as the children can keep their focus during the activity

Real pictures are strongly recommended instead of illustration, because illustration images tend to distract the children from the activity. Indonesian language proves to be helpful, especially because there are not many similar application that focus for Indonesia region.

Children with ASD must learn gradually, therefore most activity in Squizzy divided into three levels of difficulty, easy, medium, and hard. Easy level helps first timer child to adapt with the application. Meanwhile medium and hard provide more challenges for the experienced one. This level separation also helps the therapist to measure the child progress. Rewards in the form of praising words and confetti animation also given to child successfully finish the activity as an encouragement to further continue to activity.

Report feature also provided as a tools for recording each children history. Using the history data, therapist can plan activities based on each children needs. This report can also become an indicator whether a child make an improvement and where they are lacking. Library features also helps the child learn new terms and vocabulary. Child can browse all terms in the library, even play an audio to show them how to pronounce them.

## 6. Conclusion

We further explore the potential of software technology to provide assistive tools for children with ASD in the form of educational software named Squizzy. Squizzy help therapist and parents ease their therapy session by reducing the inconvenience of therapeutic tool. Squizzy is portable, developed in tablet and has low learning curve. It is designed to help the children learn gradually into sets of activity that divided into three levels of difficulty.

Simple basic color selection and the usage of real pictures proven to be effective to keep the children focus into the activity. The children also understand the real picture better than the illustration. We develop Squizzy in Indonesian because not many educational software for children with special needs using Indonesian.

Although Squizzy very helpful, the presence of the therapist or parents is still needed. The children must be given understanding that Squizzy is not a game, but a tool to helps them learn. The usage of this application also needs to be monitored as the excessive use may impact the children behavior that leads to gadget addictions.

So far, Squizzy successfully cover cognitive part of the children therapy. However, there are some therapy that focus on motoric activity, which is not easily covered by this kind of software. Further research is needed to design this kind of activity.

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