

***Design of an Interactive Tangible Sensory Toy for Autistic Children to Improve Their Learning Ability***

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**Abstract**

Autism spectrum disorders (ASDs) are highly prevalent and the number of children diagnosed with it is increasing alarmingly every year. The child's learning is majorly hindered due to poor social interaction, communication, fine motor skills, and attention span. Building these skills in them is a demanding job and interactive toys can come to teacher's and parent's rescue. Although interactive toys can play a vital role and provide a therapeutic effect on children, it is found that there is a lack of such toys in the commercial market. An attempt is made to build such a toy that is specially designed for the learning needs of autistic children aged 4-7 years. It helps in building fine motor skills, developing speech and language, and improving their attention span. This product named Giffo is based on a cause-effect principle and designed by using primary and secondary research data and observation session insights. It gives the multisensory experience that engages their tactile, visual and auditory senses. Moreover, different sensory rewards have been introduced in the form of light and sound which helps in captivating their interest and improves their attention span. It was observed significantly through usability testing that cause-effect play motivates autistic children to play for a longer time and managed to capture and increase their attention span from 1-3 minutes to around 5-8 minutes. Moreover, this product gives them a sense of control by providing a structured situation all the time which makes their learning process efficient.

Keywords: Autism Spectrum Disorder, fine motor skills, sensory toy, attention span, learning ability

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## **Introduction**

Autism is a developmental disorder characterized by impaired social interaction, verbal and nonverbal communication. According to Piaget, cognitive development was a continuous reorganization of mental processes resulting from biological maturation and environmental experience[7]. He believed that children construct an understanding of the world around them; experience differences between what they are already aware of and what they find in their environment, then adjust their ideas accordingly[8]. Autism affects the nervous system and overall cognitive, emotional, social and physical health. Due to a wide range of symptoms, this condition is also called as Autism spectrum Disorder. Common symptoms include difficulty with communication, social interactions, obsessive interests, and repetitive behaviors. People with autism range from having severe impairments to high functioning individuals with mild deficits [1]. They also find difficulties in play and are unresponsive to interactions. According to a recent survey by The Centers of Disease Control and Prevention, there is an autistic child in every 59 children in the United States of America.

Play is a medium through which children express themselves and feel a sense of control. Playing is literally synonymous with childhood. It helps them to overcome fears, anxieties, and aids in social, emotional, cognitive and physical development. But autistic children have repetitive and unusual playing behavior. They do not respond to cuddling, shy away from people, don't make eye contact or smile, doesn't respond to their names or acknowledge their toys. Their inability to get the non-verbal cues of communication makes it difficult for them to gel with people and thus appear to be aloof and distant. They indulge themselves in self and solitary play which restricts them from exploring the world around them. Freeman & Kasari (2013) explain that "it can be very difficult for parents to engage the child in reciprocal, symbolic, turn-taking play episodes without intervention"[1]. The cause of autism is still unsure but many studies say playing is considered to be remedial and therapeutic for autistic children and can aid in their development to a large extent. Many theories and studies are present about how social and physical interaction aspects like turn-taking, eye contact, expressing and recognizing emotions, shared gaze, etc. can be achieved through toys. Broadhead in one of his papers writes that early play develops nonreciprocal interaction to more reciprocal one[2]. Wainer and Barakova and Lourens also talks about the positive impact of interactive products on autistic children and describes how it stimulates social engagement among them [3].

Surveillance Year	Birth Year	Number of ADDM Sites Reporting	Prevalence per 1,000 Children (Range)	This is about 1 in X children...
2000	1992	6	6.7 (4.5-9.9)	1 in 150
2002	1994	14	6.6 (3.3-10.6)	1 in 150
2004	1996	8	8.0 (4.6-9.8)	1 in 125
2006	1998	11	9.0 (4.2-12.1)	1 in 110
2008	2000	14	11.3 (4.8-21.2)	1 in 88
2010	2002	11	14.7 (5.7-21.9)	1 in 68
2012	2004	11	14.6 (8.2-24.6)	1 in 68
2014	2006	11	16.8 (13.1-29.3)	1 in 59

Figure 1: Identified Prevalence of Autism Spectrum Disorder (2000-2014),  
<https://www.cdc.gov/ncbddd/autism/data.html>

### Significance

The alarming figures about the prevalence of autism in the survey by CDC [5] suggest how the spectrum is taking the form of an epidemic year after year. According to a study, there is a prevalence of 0.15 percent among every 43 children out of a total of 28,070 children in rural, urban, and tribal areas in the age group of 1–10 years in India [3]. Chawarska, Klin, and Volkmar (2008) in their paper mention that the signs of autism tend to appear in the early years of a child’s life. However, parents do not take the necessary steps in the initial years due to which a large number of children remain undiagnosed or do not get proper interventions. There is a lack of commercial therapeutic toys that can play a vital role in early intervention of autistic children.

Fred Rogers rightly said “Play is often talked about as if it were a relief from serious learning. But for children, play is serious learning. Play is really the work of childhood.” Every child learns through play but some play differently. The right toys designed for the right needs can contribute to a large extent in building the skills and help in early intervention. [4]

## Methodology



Figure 2: The Spastics Centre, Kanpur

In order to understand and empathize with children with autism, authors carried out research in a special school named 'The Spastic Centre'. The Spastics Centre is a school for differently-abled children of different age groups and disabilities. It is a non-governmental organization that has been working for 20 years in the field of rehabilitation. There is a physiotherapy department, counseling department for parents and early intervention sessions.

The initial few months were spent building a reputation with the children, observe and understand them. It helped both children and author to build a comfortable and emotional relationship.

## Observations

The autistic children of age group between 4-7 years were chosen for observation sessions. These children study in classrooms and have an activity area for play and other physical activities. They were observed for several sessions, pictures were clicked and videos were taken for future references. Children were observed without disturbing or interfering with them. The author interacted with teachers to clear doubts after the observation session completed. Observation sessions helped in knowing the target audience better and empathize with them to the fullest. The interactive sessions aided in collecting demographic data and other details about the childlike types of sensory challenges they face, things they enjoy doing, etc.

The activity session used to happen for **30 minutes** every day. Each session had about 7 children. Each child was observed for 15 minutes in these sessions. It was observed that Children were always accompanied and assisted by their parents. They were provided with toys like a ball, puzzle block, abacus, trampoline to jump, stairs to climb.



Figure 3: a.) Physical activities like sit ups are done during Activity period, b.) A child jumping on trampoline to build motor skills c.) Child is made to catch and throw the ball

Each toy or equipment is meant for building some particular skill e.g. Jumping trampoline is for building balance and motor skills; swing is for working on their vestibular senses, motor skills and for sensory stimulation.

Insights from observation sessions during playing session:

- Most of them involved in solitary play: We found 6 out of 7 children played on their own without interacting with their peers and were absorbed in their world. They generally did not understand how to take turns while playing.
- Had issues with fine and motor skills: they had difficulty in grabbing and throwing ball, holding pencil, etc.
- 5 out of 7 children were active. They ran around and threw ball with the help of assistance. But two children didn't respond much to instructions. They stood idle and got frustrated when asked to do sit-ups or other exercises.
- Displays poor joint attention skills: More likely to respond to joint attention rather than initiating it. They rarely made eye contact with teachers or parents or respond/follow actively to what teachers were sayings.
- Teachers had to repeat the instructions several times to make them understand.
- Loves sensory rewards like lights and sound[6]: One of the interesting insights that we gathered was that each child had unique set of interests. They enjoyed a specific sensory rewards like light, music, vibrations, pressures etc. which also implied they enjoyed cause-effect toys.
- Rewards and appreciation: Encouragement and appreciation seemed to work best with them. It made them happy and motivated them to do a given task again and again

- 4 out of 7 children indulged in imitation. When teacher gave them instructions, some of them repeated her gestures with their hands.
- All seven children had difficulty in verbal and non-verbal language and some engaged in echolalic speech.

**In classroom:**

Four participants of age between 4-7 years were chosen. They were diagnosed with some form of autism. Each participant was observed for 15 minutes every day without disturbing them and the observations were noted.

Participant 1, 5 years old



Figure 4: Participant 1

Participant 1 is an active child. She smiles and always has a happy face. She is diagnosed with severe autism. She would be reluctant to sit and whenever she gets a chance she would get up from her seat and run. She gets distracted easily and has a low attention span. She makes eye-contact sometimes and has no speech. She often produces unusual noises and shows exaggerated emotions like smiling for longer times, staring at something for a long time. But with repetitive gestures and assistance, she understands and does the task. On completion of the task, she claps on her own and smiles back for the appreciation. She struggles to walk in a straight line and has a poor handgrip as she finds difficulty in holding a pencil and write with it. She took part actively in physical activities like running, picking the colored bottle and coming back. She was a bit reluctant in doing sit-ups and didn't interact with children around. She liked to play on her own. One child was playing with a ball, she also wanted it so she went to him and snatched from him which suggests that she lacks social skills.

b. Participant 2, 4 years old



Figure 5: Participant 2

Participant 2 stays in his world and does not speak much. In the 15-minute observation session, he spent 10 minutes playing with the given toy and hardly noticed anyone around him. He doesn't respond to his name. After sometime he lost interest in the toy and started to stare into space. He blabbers a few words or murmurs poems/ songs as he is sensitive to music. His mother told him he likes to listen to music often and then starts humming the song. A peer friend was playing with a sound-producing toy and it caught his attention. He also wanted to play with it but refrained from asking for it. With constant assistance and imitations, he often imitates the actions. He has moderate gross and fine motor skills. He is shy and doesn't make eye contact and has poor social skills. He lacks a social smile, hesitates in reaching out to people and remains aloof. Even after being called 5-6 times by his name, he doesn't respond.

c. Participant 3, 7 years old



Figure 6: Participant 3

Participant 3 is a smart child. She loves to write and do coloring. She loves crayons and painting activities. In 15 minutes session, 80 percent of the time she was indulged in writing that her teacher asked her to do. She likes to sit in one place, unlike other peers. She carefully fills colors into the shape that her teacher drew in her notebook. She has not acquired speech yet and makes sounds to communicate. She cannot speak words and engages in echolalia speech. When her teacher instructs her something, she tries to repeat the sentences by making sounds. When she is alone, she stims with her hands and makes repetitive actions and gestures while looking at the ceiling. She

doesn't like loud noise and becomes restless and screams to resist it. She cries when she cannot answer her teacher or doesn't understand what her teacher wants to say. She doesn't make eye contact, shy away when someone tries to speak to her and hardly interacts with people around her. She doesn't like to move around much and prefer sitting. She keeps standing at one place and observes things around her. Her mother continuously assists her with different exercises and play

d. Participant 4, 4 years old



Figure 7: Participant 4

Participant 4 is a happy child. He has a fair set of social skills like eye contact, smiling at others and recognizing the emotions but has poor language-speech skills. He hardly speaks anything and prefers solitary play. In 15 minutes session, he was completely indulged with his block and sorting game, very few times he looked at his mom for assistance. His mother hands him the blocks and points at the places to fit them, he follows her instructions and carefully places them. When he is not able to place it properly, he rotates the block and tries to fit it. But during play, he loses his interest and starts to stare here and there. During the activity period, he is quite active. He follows instructions with the help of his mother's assistance.



Figure 8: Affinity mapping for insight gathering

Insights from interviews taken with parents and teachers

1. Parents have to look after their children all the time. They cannot leave their autistic child alone otherwise he/she might get into trouble and maybe unable to help himself/herself.
2. Many of them do not understand that their child's needs are different. They expect their child to behave in the same manner as normal children do. Due to

this thinking, many times parents think punishing the child is the right way to handle them but instead of positive reinforcement it turns out to be a negative one.

3. Parents have to deal with sensory overload almost all time of the day. This is due to the restlessness and anxiety that they face.
4. Parents find it difficult to make the autistic child sleep.
5. Structured and consistent routines help autistic children to maintain stability in their lives. Naturally, they love to follow routines. When routines break, they become restless and frustrated.
6. Teachers have to do things repeatedly daily for long time to teach them. Some children might take weeks and some even several months depending upon their skill. Gradually, they learn to greet people
7. Every autistic child is different from the other and has unique characteristics because autism has a wide variation in symptoms and its severity.
8. Other peers and children do not accept and play with their child. Making him/her socially isolated.

### Concepts and Ideation

After research, conducting interviews, observation sessions and insight gathering, Authors ideated and brainstormed on ideas and possible solutions that could work for these children. Then created some fast and dirty prototypes of few selected concepts. These prototypes were taken to children for testing and an observation session was conducted.

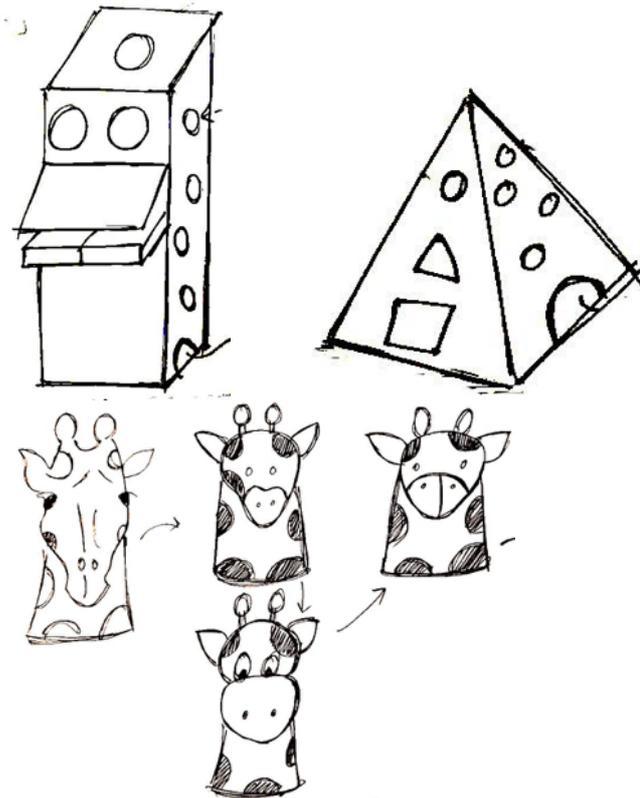


Figure 9: a.) Prototype b.) Testing



Figure 10: Prototype and its testing

After the testing of prototypes and fixing the final concept, the next crucial step was to decide the form of the toy. Number of shapes and forms were explored to best suit the needs. Initially, geometric shapes like cylinders, pyramids, cuboids and spheres were experimented.



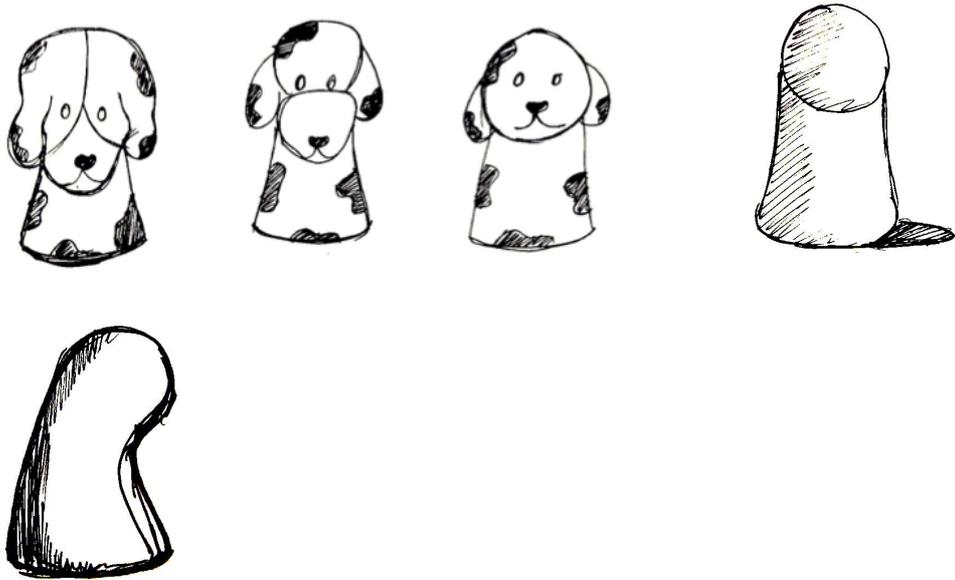


Figure 11: Form exploration from animal shapes

### **Designing for autistic children**

Designing toys for autistic children is a bit tricky because each child is different in terms of sensitivity and skills. In order to give them unforgettable and engaging experience designers have to study deeply about their lives, behaviors and feelings. Designers need to look into different aspects like how do children play, what senses they use most while playing, what attracts their attention, what things make their play interesting. Most of the toys involve three of our most used senses: sight, sound, and touch. Some toys have colorful graphics or images on them and some has light and sound which helps children to interact with it in more interesting way. Many toys have come up in market which uses these senses to teach children about letters, colors, and sound of the animals, numbers and much more.

The involvement of senses is essential to make play a bit more engaging. It acts as a positive reinforcement. The action becomes almost natural and super intuitive with very low effort. Besides these, it is really important to make toys simple yet absorbing which can help children to engage for longer time. Embedding technology into toys aids children in their development and their play.[9]

Earlier efforts were made to study autism and find ways to cure it, but since few years focus has shifted. Researchers and designers have started to study and realize the positive impact of technology on impairments of autistic children[10][11],and even came up with few guidelines on how to design toys for autistic children[8].

### **Final concept:**

Giffo is an interactive tabletop plush toy specially designed for autistic children and can be used by normal children as well. The physical design of Giffo is very simple and universal. Its shape is inspired by animal form. It has one main body which consists of three elements. Giffo being a tabletop toy enables children to sit around it and interact with it. This arrangement motivates children to interact and communicate

with their peers and builds social interaction skills like turn taking, maintaining eye-contact and understand cause-effect relationship. Children can be creative and make their own games as well while playing with Giffo. Children can take turns around Giffo when they are in a large group or a classroom.

- The outline shape of Giffo is curvy which makes it approachable, child-friendly and playful for children.
- Giffo doesn't depict any particular animal. Child can imagine it to be any animal he/she wants it to be.
- It is an engaging and novel product that aids in building social engagement skills, fine motor skills and sensory skills through principles of cause and effect play in autistic children.
- Every aspect of Giffo has been designed for a purpose. Each element focuses on some particular domain and helps in building that particular skill in the child.
- Understanding that each child is different and has unique needs, Giffo has been designed in such a manner that it caters to almost every child. It has textures and unique interactive outputs. Some playing element has a light as an output and some has sound.
- It has a round shape at the edges to ensure ultimate safety for the children. Parents can set their children free without any worries.
- The entire surface has faux fur to give it a look of a soft toy and provide tactile sensory experience to the children at the same time.
- Since it has a compact shape, it can be placed anywhere in the room. Children can even place it on table
- Moreover, this toy can be played by all children and not just autistic children. Thus, breaking the stigma of relating it with special need toys.

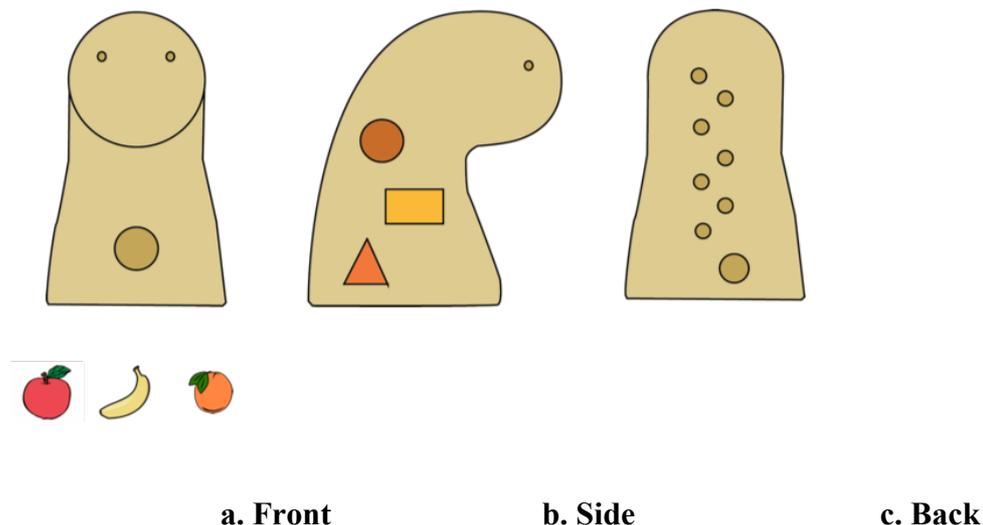


Figure 12: a.) Front side of Giffo, b.) Side of Giffo, c.) Rear side of Giffo  
 a. Front side (For Speech Language Development and Social Skill Development): the front part of Giffo is meant for building social skills and speech-language skills in children. It teaches social words like “Thank you”, “Hello” etc. which are required in daily conversations. There is a feeding compartment in the front. The Giffo kit will have food blocks. When the child feeds Giffo with different foods like fish, carrot, orange etc, it says “Thank

you” as a feedback. The feeding compartment has an infrared sensor at the base. So whenever any object is placed, it senses it and provides audio feedback. Since an autistic child engages themselves in echolalia speech, such repetitive feedback of a word helps them to retain it in their memory and make use of them in their speech. Besides, language they also learn names of different fruits and food items interestingly. Teacher and parents can teach different words to the child as audio feedback can be easily customized according to child’s requirement and pace. It is great way to teach children social behavior like sharing.

- b. Rear side (For eye-hand coordination and fine motor skill development): The rear side of the Giffo has holes. The child has to put ball into one of the holes and as a result gets a visual feedback. The rear side starts to glow with light. This feature aids child to build eye-hand coordination by targeting ball at the hole. This feature involves child in cause and effect play. This type of play brings sense of control in child and makes him/her aware about one’s actions.
- c. Sides (For fine motor skills and eye-hand coordination): The walls have 3 led lights on each side of Giffo and each LED has a switch on the side. When Giffo is powered on, one of the LED light glows randomly. The child has to switch it off using the switch. When child switches it off another LED starts to glow randomly on that side. This way child has to coordinate with the LEDs and act accordingly. This helps in building eye-hand coordination skills.

#### **Testing with autistic participants:**

The testing was done with participants who were diagnosed with some form of autism. Each session was conducted for 20 minutes.



Figure 13: Usability testing with autistic children

1. Giffo successfully grabbed the attention of children. They came close to have a look and wanted to play with it but didn't say it directly.
2. Their behavior was passive initially but when one of the children was asked to play with the toy others got interested into it. They gathered around the toy.
3. Once the child was given instructions on how to play with it, she managed to play with the toy.
4. When the child put the ball at rear side, it starts to glow. The child started to clap and gave a big smile indicating she enjoyed the feature. It engaged her finger and hands well while putting and fetching the ball.
5. The child also enjoyed the first module where Giffo says "Thank you". She tried feeding the toy again and again.
6. They showed less exploratory behavior compared to normal children.
7. They showed less cooperation in turn taking.
8. Overall, the child seemed to be engaged and the toy managed to capture her attention and interest with help of sensory rewards like light and sound.
9. The toy was usable enough as she didn't need any assistance while she was playing

The toy was effective enough because children were able to play with each feature without any assistance or problem. It managed to capture their attention for more than 5 minutes. Design was justified as product was easy to play and increased their average attention span.

## Result and Conclusion

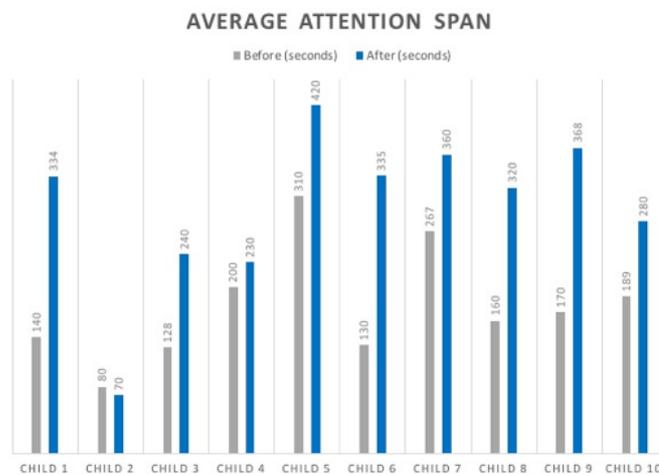


Figure 14: Average attention span

It was observed that autistic children had an average attention span of 1-3 minutes while playing with typical toys whereas average attention span increased to 5-8 minutes when they played with Giffo.

Interactive tangible toys and technologies have proven to be imperative for the intervention and treatment of individuals diagnosed with autism. It was observed significantly through usability testing that cause-effect play motivates children with autism to play for longer time. They truly enjoy sensory rewards like sound and light which is one of the important factors in increasing their attention span. Moreover, the product makes use of their special interests and gives them the sense of control by

providing a structured situation all the time for example fixed color of LED and fixed auditory feedbacks from the Giffo. The research aimed to design an interactive toy which can help autistic children. It gives multisensory experience that engages their tactile, visual and auditory senses and Giffo truly manages to fulfill the mentioned target.

The usability testing helped in measuring how usable our product is but effectiveness of Giffo in improving social, motor and language skills would be tested in future with bigger sample size. The testing would be done based on parameters like how many times they indulged in speech or language, how many times they imitated the words spoken by the toy, how many times they responded to turn-taking, how many times they made eye contact with their peers etc. Author also plans to refine the form to make it more compact and add more features like introducing easy to difficult levels to keep the toy interesting for the child. Also, many manufacturing processes need to be considered for large scale manufacturing so that it can be introduced in the commercial market and maximum number of autistic children can get benefit out of it.

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