

Designing of a Basic Mathematical Kit to Assist Mathematical Skill Development Among Children with Autism

^{I,II,III}Himanshi Vashishth, ^{III}Sangeeta, ^{III}Jyoti Sharma, ^{IV}Pankaj Tyagi

^{I,II,III}Meta University Course "M.Sc. (Mathematics Education)", Cluster Innovation Centre,
University of Delhi, Delhi, India

^{III,IV}Cluster Innovation Centre, Rugby Sevens Building, University Stadium, G C Narang Road,
University of Delhi, Delhi, India

Abstract

Autism is neurodevelopment disorder/delay which restricts people from many routine tasks such as smooth social interaction, developing logical flexibility and others. Since, mathematics is taught in highly abstract way, children with autism found it nearly impossible to do mathematics. The present research focused on developing mathematical skills among children with autism. The research focused on understanding learning needs of children with autism by observing them in real time learning situations. During observation, the primary focus was on what they could learn and how they could learn instead of knowing what they could not learn. After identifying the learning needs, it was decided to develop 'Mathematical Kit' which included hand-on activities on fundamental mathematical concepts. The design and presentation of kit was also given due consideration as children with autism enjoy working with colourful motifs. Detailed instructional and assessment plan was also developed for each activity. The entire kit along with instructional and evaluation plan was tried out with children with autism for necessary improvisation.

Keywords

Autism, Learning Needs, Mathematical Pedagogy, Mathematical Kit, Mathematical Skills.

Introduction

Mathematics is difficult for most of the people in the world because of its abstract nature. The level of difficulty becomes many-folds for differently abled children. There are very few examples where differently abled people have pursued mathematics as a career, particularly people with neurological problems. In the present study, researchers decided to understand the constraints and needs of autistic children studying mathematics. Researchers chose autism because it is a neurodevelopmental disorder. Person with autism find it difficult to learn orderly behaviour and to understand system based things. Mathematics is a discipline of systems, organization and pattern formation. Also, autism is an area where not much has been done in the field of mathematics. So, it was decided to understand the challenges faced by children with autism while learning mathematics and how their learning demands can be met by developing suitable teaching-learning tools.

Autism: Autism is a pervasive developmental disorder which is characterized by impairments in communication and social interaction. It leads to restricted, repetitive and stereotypic patterns of behavior, interests, and activities. It is a complex neurological disorder that affects the functioning of the brain. Autism affects the way the brain processes information and prevents individuals from properly understanding what they see, hear and otherwise learn. Persons with autism have to work hard to learn normal patterns of communications and ways to relate to people, unlike those of us without autism who learn this naturally, as part of our normal developmental process. Autism is a complex, lifelong developmental disability which typically appears during the first three years of life [1-2]. A number of autistic children do not even develop speech, while others rarely use language to communicate their feelings and learning. Symptoms of autism range from learning disability to social disability to severe impairments. That is why autism is also known as "spectrum" disorder.

The disorder may occur alone or with accompanying problems such as mental retardation, cerebral palsy, or seizures. Some individuals with Autism Spectrum Disorder (ASD) may require

lifelong support while others may go on to graduate from college and lead independent lives.

The most effective and well documented remedy for individuals with autism is to provide them systematically designed educational opportunities based on behavioral principles and with focus on the core areas of impairment, viz. communication and social understanding. There is no medical treatment for autism, though medication may be used to treat specific symptoms.

Symptoms to recognize child with Autism: An autistic child may look like any other child but has distinctive and unusual behavior and speech patterns.

The child may:

- show delayed language development or loss of early acquired language
- repeat or echo words and questions, reverse 'you' and 'i'
- express needs rather than emotions
- rarely or not use gestures to communication
- enjoy rotating or spinning objects
- be occupied with parts of objects like knobs, switches, wheels and pedals
- repeat the same activity for a long period of time
- appear to be hyperactive.
- be sensitive to sound or touch
- prefer routine and structure task, dislike change
- become upset or laugh for no apparent reason
- appear indifferent to pain, heat or cold
- seem unaware of danger
- avoid eye contact
- appear not to hear
- not look at things adult like looking at
- not mix with other children
- display good rote memory for nursery rhymes, commercial jingles, facts and routes.

Learning Characteristics Of Autistic Children: Children with autism demonstrate specific learning behaviours which can help teachers to easily identify them and plan the teaching course as per the needs of the children:

- (i) Visual learners: Many autistic children are visual learners though they are slow in processing information. Pictures and other visual aids cannot be shown to them in rapid succession as it often takes students longer periods to process what they have seen. They need enough time to process the images.
- (ii) Modeling: Students with autism are often good imitators if they are given enough time.
- (iii) Haptic modality: Haptic modality refers to hands-on style of learning. Children with autism are often very sensitive to tactile experiences, and they often want to touch everything they see.
- (iv) Talking to self: Children with autism talk to themselves. Self-talk can help children organize their thoughts and keep them focused.
- (v) One step at a time: A student with autism can focus only on one piece of information at a time. They find it difficult to focus on multiple aspect of a learning context. Therefore, learning experience given to autistic children should be direct and concise.
- (vi) Stay consistent: Children with autism prefer consistent learning experience. Any deviation from routine learning experience must be supported through social stories and visual aids.

Limitations Associated with Autism: Children with autism possess typical learning problems which may help educators to design and plan appropriate learning behavior for them:

- (i) **Impairments in Communication:** Children with autism have impairments in nonverbal communication which include difficulty in facial expression, use of gestures, imitation, eye contact and body postures and mutual or shared focus of attention. There may be a delay in or lack of expressive language skills. Individuals who develop speech may have a restricted vocabulary. There may be a tendency to perseverate on a topic. There are problems with comprehension of verbal information, following long verbal instructions, and remembering a sequence of instructions.
- (ii) **Impairments in Social Interaction:** Individuals with autism demonstrate qualitative differences in social interactions, and often have difficulty establishing relationships. There is impairment in the ability to read and understand social situations, and to respond appropriately. Individuals with autism have difficulty attending to relevant social cues, and shifting attention as necessary and may miss a lot of social information. Autistic children find it difficult to understand the perspective that could be different from their own. There is a tendency to play with toys and objects in unusual and stereotypic ways.
- (iii) **Cognitive Deficits:** Children with autism find difficult to attend to the relevant cues and information. They also feel challenge to attend to multiple cues. They face severe problems in abstract concept formation and reasoning. They find it difficult to plan, organize, and solve problems. Though they have relative strength in rote memory and in the ability to recall simple information, but face difficulty with encoding more complex information.

Though children with autism cannot achieve many of the milestones as compare to normal children, yet they possess specific characteristics which can be taken into consideration while designing any learning task for them. It becomes all the more important to plan mathematics learning material for them.

These children can learn better with visualization and hands-on. Anthes (2013) investigated worked with children with autism and concluded that superior mathematics skills may accompany autism [1]. Anthem observed that children with autism could also do mathematics as other normal children, particularly arithmetic. He found that some children simply recalled correct answers from memory while other children used counting and some children arrived at the answer by breaking each problem down into a set of simpler arithmetic questions. Based on extensive analysis, Anthem concluded that children with autism can also do mathematics. After understanding the complexities in learning behavior of children with autism, it became important to device activity oriented and visually impressive learning material for these children so that they can also do mathematics with fun.

Objectives of The Study

- To understand learning characteristic with children with autism
- To design activities based on identified mathematical areas
- To develop mathematical layout and teaching plan for each activity
- To conduct a field trial of the developed mathematical kit
- To analyze the outcome of the field trial

Methodology And Data Collection

The research was exploratory in nature. It started with looking into research work on autistic children to understand their personality traits. It was also decided to visit institutes working with children with autism to observe learning behaviors of these children. Following three organizations were visited to know about autism and behavior of autistic children:

- Action for Autism (Open door School), Jasola Vihar, Delhi, India
- Inspiration School, Tilak Nagar, Delhi, India
- Kulachi Hansraj Manovikas Kendra, Ashok Vihar, Delhi, India

Action for Autism, it is one of the premier organizations that work for the welfare of children with autism. The organization has done seminal work in this area. It has published several books and journals depicting multiple aspects of autism. Researcher met faculty and spent considerable time in understanding autism from the field reality. It was also decided to visit Kulachi Manovikas School for differently –abled children and personally met and observe children with autism. The visits to these centers gave researcher better insight about the behavior patter of children with autism. It was also found that color sorting, counting activity and half matching games are available for children with autism but no specific learning material was available in the field of mathematics.

Researcher spent twenty days (5 hours a day) at Kulachi Hansraj Manovikas Kendra to observe children with autism. Concerned teachers were also interviewed to know more details about social and learning behaviors of these children. Detailed observation of children helped researchers to know their peculiar behavior more closely. Following are the highlights of specific learning behavior of some of the children with autism who were observed:

Student I : Age: 10 years, Class I

Classroom behavior

- Stubborn behavior
- Used to repeat same sentence continuously when he was angry
- Comfortably communicating with other children

Learning skills and learning behavior

- Though 10 years old still he was still enrolled in grade I.
- Could do simple one digit addition
- Difficulty in doing reverse operations such as subtraction
- Could understand concepts only at concrete level
- Identify basic shapes such as triangle and rectangle
- Difficulty in differentiating among the same category shapes such as square and rectangle
- Recognition of digits but problem in placing the digits at right place

Learning preferences

- Visuals attracted him the most
- Prefers to work with hand-on rather than paper-pen work
- Loves to listen to music so music works as positive reinforcement for him
- Could not handle independent homework

Student II:Age: 10 years, Class I

Classroom behavior

- Stubborn behavior
- Frequent cry
- Not too comfortable talking to peer

Learning skills and learning behavior

- Lack concentration
- Poor vocabulary
- Poor understanding of basic mathematical concepts

Learning preferences

- Needed continuous assistance to do even the elementary task
- Needed lots of reinforcement to complete the task

Student III:Age: 7 years, Class: Pre – primary

Classroom behavior

- Polite and soft spoken
- Very less interaction with peer group

Learning skills and learning behavior

- No participation in classroom activities
- Remained in imaginary world

Learning preferences

- Love for cartoon
- Could recognize all the cartoon characters shown in TV shows

Student IV: Age: 8 years, Class: Pre – primary

Classroom behavior

- Soft spoken
- Poor social skills
- playful

Learning skills and learning behavior

- Could do ordering and seriation

- Preferred to work alone

Learning preferences

- Colorful toys
- Hand-on activities with colorful images

Student V: Age: 14 years, Class VI

Classroom behavior

- Poor social skills
- Rigidity
- Non-responsive

Learning skills and learning behavior

- Could do one digit addition
- Preferred to work alone
- Low concentration
- Could work on computer

Student VI:Age: 14 years, Class VI

Classroom behavior

- Could talk to people with little reservation
- Weak eyesight

Learning skills and learning behavior

- Could do one digit addition without problem
- Preferred to work with alphabets rather than numbers
- Attentive to learn new things
- Could work on computer
- Could extend learning in new situation

Student VII: Age: 12 years, Class VI

Classroom behavior

- Impatient
- Angry behavior
- Attacking nature

Learning skills and learning behavior

- Could do simple addition and subtraction easily
- Interested in doing new things
- Could identify shapes without problem

Extensive observation and discussion with teachers helped the researcher to develop detailed profiles of each learner. Though autism is a specific category but within the group, the population is not homogenous. Children with autism may demonstrate same traits but with varied degree of difficulty. Some traits may totally be missing from some of the children. Also, every child may have specific learning style. So, it was decided to identify most common learning challenges, particularly, mathematics learning challenges and most preferred learning styles of children with autism.

Most common challenges for children with autism in learning situation :

- lack concentration
- cannot work in groups
- cannot conceptualize higher concepts
- cannot abstract concept easily
- poor communication skills
- poor social interaction

List of identified Mathematical Challenges for children with autism:

- Difficulty in conceptualizing higher order concept
- Difficulty in doing two digit or more digits arithmetical operations
- Difficulty in doing Reversibility as an operation
- Difficulty in differentiating among geometrical shapes

Most preferred learning styles:

- Hands-on through touch and feel
- Colorful and visually attractive

Once the common concerned areas were identified, it was decided to plan activity kit based on the most preferred learning styles.

Development of Mathematical Kit for Children with Autism

After observing the learning behavior of children with autism in real time setting, researchers got better insight about children's understanding of mathematical concepts and their cognitive level. It came through observation that children with autism were ready for abstraction task. Based on the findings and study of existing web resources [3-8], it was decided to design such activities which could demonstrate abstract mathematical concepts at concrete level and could engage them for longer duration. The design and presentation of activities was given due consideration.

Scheme of Activities

(i) **Target group:** Children with autism

(ii) **Underlying premises:**

- It is important for children with autism to have a mathematical kit to develop a better mathematical understanding
- Most effective way of doing activities shall be of individual purpose because children with autism have problems while working in groups
- Activities can be instrumental in effective pedagogy as well as for assessment

(iii) **Layout of the Activities**

Following activity based kits were designed for children with autism:

(a) **Classification Nest:** It is based on mathematical concept of classification. Fig-1 shows design of activity kit.

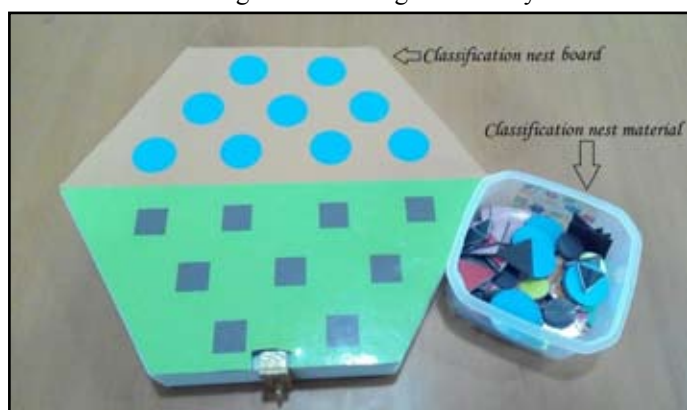


Fig.1: Classification Nest

(b) **Counting Puzzle:** It is based on mathematical concept of ordering, sequencing and counting. Fig-2 shows design of

activity kit.



Fig. 2: Counting Puzzle

(c) **Pattern Journey:** It is based on mathematical concept of Pattern Generalization. Fig-3 shows design of activity kit.



Fig. 3: Pattern Journey

(d) **Subtraction/ Addition Quiz:** It is based on mathematical concept of addition and subtraction. Fig-4 shows design of activity kit.



Fig. 4 : Addition/Subtraction Quiz

- (e) **Division Wonderland:** It is based on mathematical concept of division. Fig-5 shows design of activity kit.

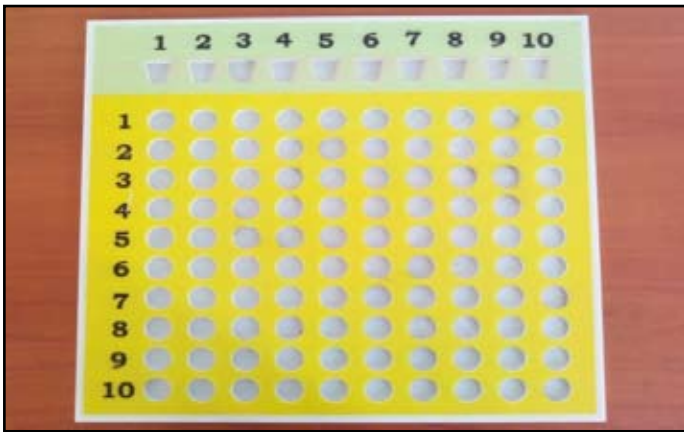


Fig 5: Division Wonderland

Each activity was designed with comprehensive instructional and assessment plan.

(iv) Field trial and Analysis

Once activity kit was developed, it was decided to do the field trial of the kit with students from the same school. Teachers were oriented before the field trials. They also became an integral part of the field trial. Each activity was tried with individual student separately. Students were given enough hand-holding to perform activities.



Figure 6: A child with autism doing Classification Nest

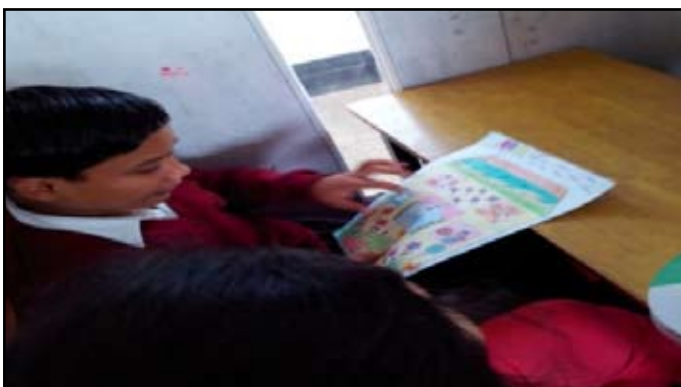


Fig. 7: A child with autism doing Counting Puzzle

Major Findings of The Field Trial

- Children with autism were able to do “Classification nest” activity
- Initially children faced problems while counting the things in “Counting Puzzle” activity. But later, they could do it effectively after researcher helped them.
- In “Pattern Journey” activity children were able to form simple pattern using shapes, symbols and numbers, shapes and symbols, alphabets and numbers. They found difficulty in forming complex pattern.
- Initially children found difficulty in making decreasing pattern but could do it effectively after assistance.
- Addition/Subtraction Quiz game was completed by majority of them but only under the guidance of teachers.

Almost all students enjoyed doing activities but they required continuous support from the teachers.

General Observations & Discussion

The main objective of the project was to make mathematics more accessible for differently abled children. Generally mathematics is kept out of reach from these children, particularly, children having neurodevelopmental disorder. Autism is one such category of differently abled children who face moderate to severe behavior and learning disorder. Though these children lag behind in achieving cognitive milestones at normal pace, but they are capable of achieving important milestones at different pace under different learning conditions. The development of project at different phases clearly highlighted the need of developing attractive, colorful and hand-on activities to develop in them basic mathematical understanding. As project developed through theory to practice, the belief that such children also possess inherent ability to think mathematically grew stronger and stronger. These children require more close support and better hand holding. These insights helped researchers to form the layout of the games/ activities. Through activities layout, researchers prepared instructional manual along with list of questions. These questions and concrete material helped researchers in field trial of the kit. Specifically designed mathematical kit allowed them to experience mathematical concepts in playful manner. Activities helped them cognitively as well as socially. They became more participative and socially active. They were able to engage for longer duration and helped to develop their concentration and attention span. Classification activity was enjoyed by majority of the students as it was very colourful. Children could make simple patterns using shapes, numbers and with combination of both. Subtraction/addition game was also helpful for them because cue card has visuals through which they could be to count and those visuals they were able to do addition and subtraction. They could make increasing pattern like 10, 20, 30, 40....Classification activity had colors and different shape, that's why children enjoyed doing that activity. Division activity was fun for them. Through this activity they were able to do counting, placing the necessary piece at the required place and after placing they were able to tell the necessary answer. In all through the way, teachers had to provide necessary support in understanding the task. It was also important to ask conceptual questions simultaneously.

Conclusion

The present research has strengthened the belief that mathematics is way of thinking and thus can be accessible to all people. Human beings are born with inherent neurological design to think and work

mathematically. In regular scenario, Mathematics is considered a dull and difficult subject. Not many students enjoy studying mathematics. Situation is more alarming for differently abled students. These students are left on their own to struggle with the subject. With no problem guidance and diligent efforts from the system, these students left mathematics at an early stage or don't even start with it. Children with autism face difficulty in doing abstract thinking or mental operations. Therefore, mathematics learning becomes a challenging experience for them. In such a scenario, it is important for the teacher to simplify mathematical task by bringing mathematical concept at concrete level. Since these children have different learning needs and they can learn better in different learning conditions, it is important for the system to design different mathematics curriculum for them. Regular course content may not match the pace of their cognitive and social development. It does not mean that these children cannot do mathematics. They can also develop necessary mathematical skills but at their own pace. They shall not be forced either to adjust to the regular system or to withdraw from the system. We must modify the system as per their needs and speed. Standard methods of teaching and evaluation do not work for them. They need patience, space and unconditional support from the teacher and parents to feel motivated and worthy. The present research clearly indicates that children with autism are capable of thinking mathematically. They are capable of doing logical thinking demonstrated through specific task such as classification, ordering, differentiation and logical operations. These logical operations are the stepping stone of mathematics learning. The present research gives an insight into the world of children with autism. It breaks the stereotypes related to them such as social isolation, inability to handle abstraction and lack of concentration. Children with autism are more prone to such limitations but they can be taken out in the thinking world where they can participate and feel accepted. "Basic mathematical kit for children with autism" is a process of observation of learning behaviour, developing mathematical ability and responding to mathematical challenges of children with autism.

Acknowledgment

The research team acknowledge the support of students and teachers at KulachiHansrajManovikas Kendra, Ashok Vihar, Delhi, staff at Inspiration School, Tilak Nagar, Delhi and experts at Action for Autism (Open door School), Jasola Vihar, Delhi for providing them necessary support, guidance and time to carry out the work. The authors acknowledge the Cluster Innovation Centre, University of Delhi, for all infrastructural support and financial assistance to carry out the research work.

References

- [1] Anthes E. (2013). *Superior math skills may accompany autism*. <http://sfari.org/news-and-opinion/news/2013/superior-math-skills-may-accompany-autism-study-suggests>. Retrieved online on August 16, 2016
- [2] Lord C., Cook E., Leventhal B. & Amaral D. (2000). *Autism Spectrum Disorders*. *Neuron*, Vol. 28, 355–363, University of Chicago.

Website Resource

- [3] Zander E (2004). *An introduction to autism*. http://www.autismforum.se/gn/export/download/afoversattningar/Introduktion_om_autism_engelska.pdf. Retrieved online on August 21, 2016

- [4] *Scottish Intercollegiate Guidelines Network (2014). Autism Spectrum Disorder*. <http://www.sign.ac.uk/pdf/pat98parents.pdf>. Retrieved online on July 25, 2016
- [5] *Alberta Learning Cataloguing In Publication (2003). Teaching Students with Autism Spectrum Disorders*. <https://education.alberta.ca/media/511995/autism.pdf>. Retrieved online on July 25, 2016
- [6] <http://www.autism-india.org/>. Retrieved online on March 2, 2016
- [7] *Online Learning Tools & Software*. <http://www.autismspeaks.org/family-services/resource-library/online-learning-tools-software> Retrieved online on March 2, 2016
- [8] *Educating Autistic Children with an Online Curriculum*. http://www.time4learning.com/autism_education.shtml Retrieved online on March 2, 2016