Using virtual manipulative to improve motoric skill in autism

N W Damayanti\textsuperscript{1,2}, Purwanto\textsuperscript{3}, I N Parta\textsuperscript{3}, T D Candra\textsuperscript{3}, S N Mayangsari\textsuperscript{2} and R P Murtikusuma\textsuperscript{4}

\textsuperscript{1}Doctoral Program of Mathematics Education, Universitas Negeri Malang
\textsuperscript{2}Department of Mathematics Education, Universitas Wisnuwardhana
\textsuperscript{3}Department of Mathematics Education, Universitas Negeri Malang
\textsuperscript{4}Department of Mathematics Education, University of Jember
wahyu_nia07@yahoo.co.id

Abstract. Virtual manipulative can be used as a tool for supporting learning mathematics for all students. Virtual manipulative can be related with the general academic curriculum and student activities. Virtual manipulative can provide students with a chance reverse of mathematical concepts and ultimately exhibit measurable learning skills. If a student is using virtual manipulative, they can use their hand coordination to create something new. Motoric skill is related to thinking ability. Motoric skill plays an essential role in thinking ability for student. This study aimed to explain how virtual manipulative can improve motoric skills. This research is descriptive qualitative research. The subjects of this study were students who were diagnosed with autism at primary and secondary levels. The results showed that learning mathematics with a virtual manipulative made the students interested in following the learning path. They tinkered with virtual manipulative coordination between the eyes and hands. Some of the motoric activities they did during math learning included counting different fingers, writing numbers that appeared on the computer screen, and composed a puzzle. Learning packed like this can increase the interest of autistic students to learn mathematics.

1. Introduction
Autistic students have the right to education like other normal students. Children with Autism Spectrum disorder (ASD) face many challenges in their life. They hope to get the learning such as learning mathematics. Autism Spectrum Disorders is a long lasting developmental disorder [1]. Learning mathematics can use manipulative. Virtual manipulative are one of the manipulative which are used with software. We can use it with devices like handphone, computer and laptop. If we use a computer, the student can use it during learning. The use of technology can support success in learning mathematics. With the technology, can make learning mathematics fun and easy to follow by students. The existence of various colourful objects can make autistic students interested in learning math.
Students with autism require special handling during the learning of mathematics regarding both educators and learning tools. Virtual manipulative can be used for autistic student. Many researchs suggests manipulative for learning with autistic students. Manipulative also was used for the student with learning disability [2].

Algebblocks, geometric shapes, fraction strips, and pattern blocks are all examples of manipulative that may be found in mathematics classrooms [3]. Virtual manipulative can connect objects that you make, move, and change to other representations [4]. Manipulative use is related to the motoric activity. Virtual manipulative are more flexible when applied and require less material than concrete manipulative [5]. If we use manipulative, we can train our hand and eye coordination. In essence, manipulative use may be related to motoric activity.

Satsagi and Bouck claim that virtual manipulative can be useful for use in learning mathematics [2]. Virtual manipulative are better at expressing mathematical ideas. When students use virtual manipulative, they can freely depict objects in mathematics [4]. Motor skills can be a big problem for autistic children [6].

Activities related to gross motor skills that require coordination, such as various types of sports, or even simple tasks, such as jumping can be challenging for a child with autism. Children with excellent motor skills tend to have high motivation in performing their activities [7]. When doing exercises related to motor skills such as games related to motor skills, it can help children feel successful in starting a movement and allowing children to complete it [6].

Autistic students have a weakness in motor skills [7]. They find it difficult to carry out activities related to the coordination system. Therefore, an intervention is required to train their motoric skills. Virtual manipulative can encourage students to create representations of their mathematical ideas.

2. Method
This type of research is qualitative research. All participants were male. This study has the purpose observing the use of virtual manipulative and motor skills of autistic students when using virtual manipulative. The study was conducted on three middle school students who were diagnosed with autism. The data in this study were obtained from the observation of the use of virtual manipulative by
students.

Research steps undertaken included (1) designing learning activities with virtual manipulative (2) preparing virtual manipulative to be used in the form of computer and mobile phone (3) selecting research subjects (4) observing the use of virtual manipulative (5) data reduction (6) data analysis. The data in this research were analysed through qualitative approach. Qualitative data analysis were done in these steps: (a) analysing all data from various sources, i.e. from student work result, „researcher” observation, and the results of field note (b) concluding.

3. Result and Discussion

Researchers conducted observations to autistic schools to find out information about autistic students in the school, motoric abilities, and students' skills. During the initial observation phase, interviews were also conducted with teachers about the tools used for students in inclusive education. Based on the results of observations, autistic students tend to be challenging to be able to add numbers 7 and 5 then determine the effects of the sum of the two numbers. Students make a small circle to find the amount of the two numbers. The following is an example of the work of autistic students in addition to numbers.

![Figure 3. Results of students' work about the sum of two numbers.](image)

When observed the work of autistic students in LKS, they tried to concretize abstract conceptions of numbers. This can be seen by the activity of students making circles that describe the figure. Autistic students have difficulty getting directly into abstract mathematical concepts. The results of student work in activities related to fine motoric skills in the form of coloring objects are as follows.

![Figure 4. The results of activities coloring students A.](image)
Autistic students are interested in colouring activities. They loved to explore with the colour given. Colouring activity is one of the activities related to motor skills. Researcher also observed about the behaviour of autism student. Student A screamed in class during learning because they could not play the grass which they brought to class. Student G did not work on LKS, but he played the worksheet given. At the time of observation outside of learning it was found that the overall behaviour of autistic students tended to be alone and not socialize with friends. During the view, there were no social activities between friends. They enjoyed their world.

When learning takes place, some students are engrossed in playing their puzzles when the teacher explains on the board. The student has completed his work quickly. So that when he is finished, the teacher must provide enrichment to the student. The following is an overview of the activities of autistic students during learning.
At the beginning of learning the students are given guidance on how to use virtual manipulative. Autistic students tend to be difficult to concentrate. They tend to be engrossed in their world. To train them using virtual manipulative is not easy. Only a few students can capture the information the teacher submits. Here is a picture of a student who successfully uses a virtual manipulative. This student uses GeoGebra to draw a graph of the quadratic equation with virtual manipulative. He tweaked the icons that are in GeoGebra. The motor activity that coordinates the eyes and hands of the students appear

Based on the observations made by researchers, mathematical learning done when using virtual manipulative was a study of drawing graphs of linear and quadratic equations. Before the implementation of teacher learning to design education that will be done. In the early stages of virtual manipulative teacher learning that will be used then each student is given the opportunity to manipulate the manipulative. Teacher showed the GeoGebra to be used to students A, B and C then instructed them to draw a graph with GeoGebra. Student A was taught using virtual manipulative by showing figures. But he has not been able to use and pay less attention to instructions from teachers.

Student B did not pay attention the instruction of the teacher. He played anything around him. At the time of observation, we found that the behaviour of most autistic students showed the behaviour to be alone and not socialize with friends. During the observation, we could not saw the social activities among friends. They enjoyed their world. During study, Students B could not concentrate. He was busy playing the toys in his hands.
During the course of the learning, student C tend to be curious about the virtual manipulative. He tinkers in graphmatica and can produce graphs like below. He created a graph $y = x$ then he tried with the other equation $y = x + 1$. Here are the results of short interviews of researchers and student C:

R: "How did you draw the graph?"
A: (silence then pointing at an icon) "this."
R: "What graphs are you drawing?"
A: $x$ and $x + 1$. (then dodging)

Various interventions are available to individuals with autism. They can be broadly grouped into two types: the interventions targeting specific behavioural outcomes (i.e. focused intervention) and the interventions addressing broader learning. In the teaching of autistic students, particular strategies are needed. Teaching strategies are the instructional tools that interventionists will use to assist learners to acquire target behaviours [8]. In explaining the use of virtual manipulative, instructions did not an easy thing especially for autistic students. Despite the fact that autistic students have difficulty concentrating for a long time, there are students who want to know something new. The use of virtual manipulative in the form of geogebra and graphmatica software can encourage the agility of their hands in drawing graphics, sharpness of the eyes and skills in receiving information from teachers. Intervention in mathematics learning in the form of virtual manipulative use can lead to the achievement of success in learning for autistic students [8]. This is because autistic students have difficulty in accepting the concept of classified as abstract.

**Figure 10.** Students’ activity.

**Figure 11.** Linear graph.
Virtual manipulative helps students to understand mathematical concepts and improve mathematical achievement. Virtual manipulative can be used to show puzzles, animations, and simulations [9]. Manipulative are objects facilitate better understanding of abstract mathematical concepts or properties [5]. Manipulative was divided into two kinds of concrete manipulative and virtual manipulative [10]. The kinds of manipulative aimed assist students in learning mathematics. In general, manipulative role in mathematics learning is illustrated below.

![Figure 12. Manipulative role in mathematics learning.](image)

Virtual manipulative have the potential for teachers and students in mathematics learning. Students’ interest in computers and the motivation can be seen with virtual manipulative, and teachers can take advantage of their students’ increasing ability to use this technology. To better understand these new educational tools, teachers should try virtual manipulative in their classrooms, researchers should study the use of virtual manipulative in educating students with disabilities, and teacher educators should prepare pre-service and in-service teachers to implement this technology with their students [10]. Students can also access virtual manipulative through several sites available on the internet. Tables below provide virtual manipulative as follows.

| Websites            | Web Address                          |
|---------------------|---------------------------------------|
| National Library of Virtual Manipulative | http://nvlm.usu.edu/                   |
| eNLVM                | http://envlm.usu.edu/                  |
| Illuminations       | http://illuminations.nctm.org/         |
| Interactivate       | http://www.shodor.org/interactivate/activities/ |
| MathTools           | http://www.mathforum.org/mathtools/    |
| Arcytech            | http://arcytech.org/java/             |

4. Conclusion
The existence of intervention in the form of the use of manipulative teacher learning is essential for teaching autistic students. Autistic students’ math learning differs from regular students. Learning tools that appeal to autistic students are needed. Manipulative use can make students more active in motoric activity, especially in excellent motoric skills in the form of eye and hand coordination. The motoric activity that students did with virtual manipulative was draw simple graphics with Graphmatica and Geogebra.
Acknowledgements
This research was funded by Direktorat Riset dan Pengabdian Masyarakat; Direktorat Jenderal Penguatan Riset dan Pengem- bangan; Kemenristekdikti for Penelitian Disertasi Doctor 2018

References
[1] Bello-Mojeed M, Ani C, Lagunju I and Omigbodun O 2016 Feasibility of parent-mediated behavioural intervention for behavioural problems in children with Autism Spectrum Disorder in Nigeria: A pilot stud Child Adolesc. Psychiatry Ment. Health 10 (1) p 1-8
[2] Satsangi R, Bouck E C, Taber-Doughty T, Bofferding L and Roberts C A 2016 Comparing the Effectiveness of Virtual and Concrete Manipulative to Teach Algebra to Secondary Students with Learning Disabilities Learn. Disabil. Q. 39 (4) p 240–253
[3] Uribe-Flórez L J and Wilkins J L M 2017 Manipulative Use and Elementary School Students” Mathematics Learning Int. J. Sci. Math. Educ. 15 (8) P 1541–1557
[4] Tucker S I 2016 International Perspectives on Teaching and Learning Mathematics with Virtual Manipulative 7 p 41–69
[5] Bouck E C, Satsangi R, Dought T T and Courtney W T 2014 Virtual and concrete manipulative: A comparison of approaches for solving mathematics problems for students with autism spectrum disorder J. Autism Dev. Disord. 44 (1) p 180–193
[6] Sher B 2012 Early Intervention Games (San Fransisco: John and Wiley)
[7] Kurtz L 2008 Understanding Motor Skills in Children with Dyspraxia, ADHD, Autism, and Other Learning Disabilities (London: Jessica Kingsley)
[8] Matson J L and Chiang H 2017 Curricula for Teaching Students with Autism Spectrum Disorder (Netherlands: Springer)
[9] Samioglu M and Siniksaran E 2016 Embedding Virtual Manipulative into Middle School Mathematics Curriculum Anthropol. 25 (3) p 207–213
[10] Bouck E C and Flanagan S M 2010 Virtual Manipulative: What they are and how teachers can use them Interv. Sch. Clin. 45 (3) p 186–191