Research Brief

Incorporating Manipulatives into Classroom Practice

Matthew Cardano, Loyola University Maryland

Abstract

This article proposes the use of manipulatives in secondary mathematics classrooms. Referring to scholarly sources throughout, it describes the value that manipulatives provide to students as well as the role that they can play in students' progression towards mastery of topics. It is a teacher's responsibility to have students utilize manipulatives to further enhance their learning and to conduct their own explorations and/or representations. Evidence is provided as to just how beneficial manipulatives can be to the mathematical experiences of diverse learners.

Introduction

As adolescent learners continue to diversify and advance, educators must also continue to expand their mathematical palette and find unique ways to present information. While computations are the basis of the content area, there are other actions that teachers can be taking in order to approach the learning process with more variety. Specifically, the incorporation of manipulatives can strengthen the levels of understanding among students. Manipulatives are concrete learning materials that help students represent problems either physically or virtually (Jones, 2012). Decades of research has supported the value of manipulatives in the classroom and making the mathematical experiences more meaningful for students. Despite the evidence, there has been a "sharp decline in the use of manipulatives as students progress through the grades, to the point where there is little use of manipulatives in secondary school mathematics classes" (Jones, 2010, p. 2). A potential reason for this decline, specifically as of late, is the COVID-19 pandemic, as teachers are now challenged to catch students up on critical math skills without restricting them to grade-level content. Teachers may also fear that such activities distract from meeting objectives and scoring well on assessments; however, if given the chance, manipulatives can positively affect both of these. Thus, allow yourself to be reintroduced to this teaching tactic in order to fully understand the significance of elevating mathematics beyond the textbook.

When presented with the term "manipulatives" in a mathematical context, most educators instantly think of building blocks, spinners, or some other form of hands-on tool. And while these are all very useful at the elementary level, what about when students progress to secondary levels of math? Over time, this sedentary definition of manipulatives has changed; specifically, "Virtual manipulatives are one technology tool that teachers have been encouraged to implement to enhance student learning" (Reiten, 2020, p. 56). Students love technology, and incorporating virtual manipulatives into lessons can help with student engagement as well as ensuring deeper comprehension levels. There are also many instructional benefits, such as differentiation points, instant feedback, and reteaching opportunities (Reiten, 2020). The integration of technology as a manipulative will be sure to further student development and conceptual understandings.

Example:

Compare these two lesson objectives:

- Lesson 1 (no manipulatives):
  Students will be able to combine like terms through completing examples from their textbook.

Research Brief: Incorporating Manipulatives (*continued*)

- Lesson 1 (with manipulatives):
  Students will be able to combine like terms through an interactive Desmos Activity that they will progress through on their iPads.

The difference between these two lessons, just based off the objective alone, is monumental. If you compare the two in terms of opportunities for student exploration, the Desmos Activity, which serves as a virtual manipulative, does just that. Textbook problems have been embedded into math classes for generations, but virtual manipulatives (and non-virtual) can allow for "...students to offload computational aspects, work through problems, connect multiple representations, and encourage student engagement" (Reiten, 2020, p. 63).

For this innovative strategy to work, teacher must instruct students how to use the virtual manipulative at hand. Especially if students are unfamiliar with a specific technological tool, "The teacher will need to orient the students to its functional features" (Anderson-Pence, 2020, p. 3). This orientation must occur at the beginning of lessons, and if explained thoroughly, it will lead to a proper facilitation of students' use of and learning with the virtual manipulative (Anderson-Pence, 2020).

Backing #1: The National Council of Teachers of Mathematics (NCTM)

To further extend this push for manipulatives in secondary mathematics, attention should be directed to The National Council of Teachers of Mathematics (NCTM) and one of their eight high level instructional practices: Use and connect mathematical representations. The NCTM further describes this practice with the following position: "Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving" (NCTM, 2014). Manipulatives are the connecting pieces between simply regurgitating a skill and being able to actually represent the concept to solve problems. Too often in mathematics, students act as answer machines and are only able to successfully repeat a specific process; they prefer to perform computations that they will need to know for an upcoming assessment without truly understanding the reasoning and connections behind their thinking. These learning tools can help "...shape the way children think and the understandings they gain from completing tasks" (Jones, 2012, p. 47).

Backing #2: Marilyn Burns, Mathematics Manipulative Advocate

Marilyn Burns, a respected manipulatives authority, has dedicated her life and career to extensive research on the advantages that manipulatives provide students as well as teachers in the classroom. Mainly, "Ms. Burns urges mathematics to stop teaching standard algorithms and start having children invent their own methods" (Burns, 1994, p. 471). Now providing videos and/or demonstrations of common manipulatives, the advocate strongly believes that these tools can help to improve attitudes and prevent math-related anxiety within students (Furner & Higgins, 2022). Especially at the secondary level, math tends to become more and more daunting for some students. It is imperative that teachers continue to grow and come up with innovative ways for students to learn new material while at the same time, forming better relationships with the content area as a whole and minimizing any negative stigma towards mathematics. Let the following quote, by no other than Burns herself, serve as an example for math teachers that have not figured out how to implement manipulatives into their teaching just yet:

> *"I am a teacher who has embraced the call for change fully and completely. I've made shifts in my teaching so that helping children learn to think, reason, and solve problems has become the primary objective of my math instruction. I do not give assignments on which the children can be successful by performing rote operations whether or not they understand what they are doing. I do not give timed tests on basic facts. I make calculators available for students to use at all times. I incorporate a variety of manipulative materials into my instruction... I want children to organize their ideas on paper themselves and to use symbolic representations in ways that mean something to them" (Burns, 1994, p. 472).*

Remember that enforcing such a shift within teaching practices will not happen all at once. Educators will be forced to rethink how they go about teaching their lessons, thus reevaluating their knowledge as to how all types of learners may learn best.

Figure 1

Some Key Uses for Manipulatives

Adapted from: hand2mind (n.d.)

Research Brief: Incorporating Manipulatives (*continued*)

Backing #3: Maryland State Department of Education (MSDE)

The Maryland State Department of Education (MSDE), continuing its strive for equity and excellence, has heard the voices of Marilyn Burns and other math manipulative advocates. In alignment with the NCTM, the Standards for Mathematical Practice (SMPs) offer specific areas that teachers should be seeking to develop student expertise (MSDE, 2022). Specifically, the fifth SMP is where manipulative usage can be alluded to: "Use appropriate tools strategically" (p.3). This practice standard claims that mathematically proficient students must consider all available tools when going about solving a problem; these tools include, but are not limited to, "pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software" (p.3). Notice how both handheld and virtual manipulatives are included within successful mathematical practice. Also, take note of the next part of the fifth SMP, which further requires students to "make sound decisions about when available tools might be helpful, recognizing both the insight to be gained and their limitations (MSDE, 2022, p. 3). As student engagement improves, they will simultaneously be working closer towards an advanced level of expertise. This directly correlates to Marilyn Burns' ideology, as she voiced her method of planning lessons that grants students the opportunity to have autonomy over their mathematical journeys (Burns, 1994). Introducing students to manipulatives is a step in the right direction, but still a bit too surface level. To truly see impacts on student achievement, teachers must teach students how to use manipulatives as well as have them conduct their own explorations; it is more than possible that students discover something that the teacher had not thought of previously, thus raising teacher development levels, too.

Summary

Teachers will see the positive effects on student learning that manipulatives can have once they begin to become comfortable with them themselves; only then will students be able to dive deeper into mathematical contexts and conduct thorough explorations through higher-level thinking. Manipulatives encourage students to "represent abstract mathematical concepts in varied concrete, tactile, and visually rich ways," thus forming deeper connections with the material (Jones, 2010, p. ii). Seeing how advocates, such as Marilyn Burns, have worked tirelessly to portray the significance of manipulatives in math, along with the stances and positions of spearheading organizations like the NCTM and MSDE, there is no question that there are ideas put into place that recommend students utilize manipulatives in order to increase proficiency. As students continue to gain this firsthand experience, they will be able to more effectively apply their newly acquired knowledge to the world outside of the classroom. Which, at the end of the day, is an educator's biggest accomplishment.

References

- Anderson-Pence, K.L. (2020). Virtual manipulatives: Making effective instructional choices. *Colorado Mathematics Teachers, 53*(1), Article 3. https://digscholarship.unco.edu/cmt/vol53/iss1/3
- Burns, M. (1994). Arithmetic: The last holdout. *The Phi Delta Kappan, 75*(6), 471–476. https://www.jstor.org/stable/20405143

- Furner, J.M. & Higgins, C.M. (2022) Propensities by grade of math anxiety levels K-12: Addressing mathematics dispositions and how manipulatives may help. *Transformations, 8*(1), Article 1. https://nsuworks.nova.edu/transformations/vol8/iss1/1/
- hand2mind. (n.d.). *Benefits of math manipulatives*. https://www.hand2mind.com/resources/benefits-of-manipulatives#
- Jones, A. (2010). *Secondary school mathematics teachers' views of manipulatives and their use in the classroom.* [Doctoral dissertation, University of Ottawa]. uO Research. http://dx.doi.org/10.20381/ruor-6301
- Jones, J.C. (2012). *Visualizing elementary and middle school mathematics methods*. John Wiley & Sons.
- Maryland State Department of Education. (2022). *Standards for Mathematical Practice*. Author. https://www.marylandpublicschools.org/about/Documents/DCAA/Math/StandardsForMathematicalPractices.pdf
- National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Author.
- Reiten, L. (2020). Why and how secondary mathematics teachers implement virtual manipulatives. *Contemporary Issues in Technology and Teacher Education, 20*(1), 55-84. https://citejournal.org/volume-20/issue-1-20/mathematics/why-and-how-secondary-mathematics-teachers-implement-virtual-manipulatives.

Matthew Cardano is a current senior at Loyola University Maryland. With a major in mathematics and a minor in secondary education, Matthew is completing a full year of student teaching in an Algebra II classroom at Baltimore Design School. He is from Red Bank, New Jersey, and plans to return to teach in his hometown in the fall of 2024.