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TEACHERS OF MATHEMATICS

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Learning mathematics through Minecraft

Technology has a natural drawing power for today's youth. It stimulates their interest, curiosity, and creativity (Dawley and Dede 2012). Students are naturally inquisitive and explore without fear of failure when using technology. All these traits help them investigate mathematics within game-based technology. One of the popular game-like environments that children enjoy is Minecraft, a Web-based environment that can be downloaded from the Internet (<https://minecraft.net/>) onto a smart-phone, iPod®, iPad®, or computer.

Interacting with a virtual world

Minecraft, created by Markus Persson and Jens Bergensten, has captured the attention of many users and has a special appeal for the younger user because of its three-dimensional Lego®-like environment in which the user can build and interact with a virtual world. Minecraft is an open-world game within a sandbox environment that has no specific goals for the player to accomplish while in default settings, thus allowing students a large amount of freedom in choosing how to play the game. The world is made of blocks of different colors and simple patterns that represent a variety of organic and hand-crafted materials.

Initially, play is from a first-person perspective in a 360 degree environment and involves breaking and placing blocks. Although players move freely across the world, objects and items can be placed only at fixed locations relative to positioning on a grid. Players can gather these material blocks and place them elsewhere, allowing for various building projects.

The game has two modes: creative and survival. In the creative mode, players have access to unlimited blocks and can fly freely around the world. The survival mode has four levels. The easiest (peaceful) level removes any hostile creatures; the harder the level, the more advanced the hostile creatures. For teaching

mathematics, the creative mode is a perfect sandbox environment to explore such concepts as algebraic patterns, measurement, perimeter, area, and volume.

Building a coastal community

Within a three-day math unit in a third-grade classroom, students used Minecraft to explore area and perimeter. First, the teacher reviewed the definition of *perimeter* and *area*. Using a class set of iPods with Minecraft downloaded and installed, students were asked to go to the creative mode to build a coastal town with a pier area of 12 square meters, a bait shop with a perimeter of 12 meters, a restaurant with an area of 24 square meters, and a square store with an area of 16 square meters (see **fig. 1** and **fig. 2**).

Notice the Lego-like feel of the virtual world. Each square block represented a cubic meter. The units were carefully chosen to give students choices of stone with different dimensions. After building their structures, they compared and discussed the similarities and differences among one another's configurations. Questions were raised about the different choices of shapes for the buildings (narrow and thin or almost square). The variety of possible dimensions inspired a rich discussion. Students found that only one set of dimensions was possible for the store (a square building). This discovery led to making conjectures about the structures' shapes and their relationship to perimeter and area. The difference between the two terms became clearer with the visual imagery as students used the length of the side of one cube repeatedly to measure the distance around (perimeter of) a shape and counted the number of squared units forming the base shape (area).

Designing a scenario means providing a purpose for students to use the skills they have learned in class to explore and achieve a greater depth of understanding. Minecraft forms a medium to explore possibilities.

Playing with mathematical ideas

Minecraft can be used for instruction, remediation, or extension activities for anytime, anywhere learning. Students typically play Minecraft at home, at the game field, and riding in the car—extending their learning outside the walls of the school. Offering a Minecraft video, posted on the class website, is a great way to get your students started. Encourage them to do the activity on video and take a screenshot of their final product to share with others at school. Play becomes an opportunity to explore mathematical ideas within an online community.

Students working with Minecraft are unafraid to try a different configuration, to make a new tool, or to discover the attributes of a stone. Their only limitations may be what questions to ask and which problems to solve, and that is where the teacher contributes meaningful scenarios and pertinent questions reflective of the curriculum. See **table 1** (pp. 58–59) for more Minecraft activities.

REFERENCE

Dawley, Lisa, and Chris Dede. 2012. "Situating Learning in Virtual Worlds and Immersive Simulations." In *The Handbook of Research for Educational Communications and Technology*. 4th ed. Edited by J. Michael Spector, M. David Merrill, Jan Elen, and M. J. Bishop, pp. 723–34. New York: Springer.

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FIGURE 1

On class iPods that had the Minecraft application already installed, students used the creative mode to build a coastal town. This is a screenshot of a pier area and bait shop.



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FIGURE 2

This screenshot shows the restaurant.



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Each month, this section of the Problem Solvers department features a new challenge for students. Readers are encouraged to submit problems to be considered for future columns. Receipt of problems will not be acknowledged; however, those selected for publication will be credited to the author. Find detailed submission guidelines for all departments at www.nctm.org/tcmdepartments.

TABLE 1

The following activities are organized by grade and the Common Core State Standards for Mathematics (CCSSM) (CCSSI 2010) to show different mathematics activities possible with Minecraft.

| Additional Minecraft mathematics activities | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kindergarten CCSSM | Use of Minecraft |
| Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from. | Use cubes to build trains with a certain number of cubes (numbers 11–19); have student count and then group in trains of 10 to gain foundation for place value. |
| Identify and describe shapes. Analyze, compare, create, and compose shapes. | Students can identify and create squares, rectangles, and triangles. Analyze, compare, create, and compose shapes in two and three dimensions. |
| Grade 1 CCSSM | Use of Minecraft |
| Represent and solve problems involving addition and subtraction. Understand and apply properties of operation. Add and subtract within 20. | Add and subtract blocks using numbers 1–20. Work with simple equations and have students create block structures to illustrate problem. Have them create structures by following an equation, and have another student guess the equation they used. |
| Measure lengths indirectly and by iterating length units. | Measure length of buildings by iterating length of cubes. |
| Grade 2 CCSSM | Use of Minecraft |
| Represent and solve problems involving addition and subtraction. Add and subtract within 20. Work with equal groups of objects to gain foundations for multiplication. | Build solid towers with a base of 2 and count by twos to find the total number of cubes used. Repeat with a base of 3, base of 5, and base of 10. Use flats of 10 and towers of 10×10 to add and subtract three-digit numbers. |
| Reason with shapes and their attributes. | Partition rectangles made with twelve cubes into two, three, or four equal shares. Describe the shares using the words <i>halves</i> , <i>thirds</i> , <i>fourths</i> , and <i>quarters</i> ; and use the phrases <i>two-halves</i> , <i>three-thirds</i> , and <i>four-fourths</i> . Recognize that equal shares of identical wholes need not have the same shape. |
| Grade 3 CCSSM | Use of Minecraft |
| Numbers and operations in base ten | Build solid towers with base of 10 and chimneys with various heights. Estimate the number of cubes. Write an equation using both multiplication and addition to find the number of cubes in the structure. Take a picture and send it to the teacher. What would you build to show $3 \times 10 - 8$? Take a picture and send it to the teacher. |
| Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures. | Have students build buildings with the same perimeter and different areas, and with the same area and different perimeters. |

| Grade 4 CCSSM | Use of Minecraft |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gain familiarity with factors and multiples. | Determine whether a given whole number in the range 1–100 is a prime or composite number. See www.youtube.com/watch?v=IDr6v9HsmxQ |
| Use the four operations with whole numbers to solve problems. | Have students build representations of houses, complete with windows and doors. Students figure out the total cost of the house if each cube is worth \$12. Students must determine how many cubes they used by multiplying to find the area of sides and subtracting the area of the windows and door. Then they add wall areas together and multiply by \$12 and set a budget they cannot exceed. |
| Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers. | Use rods made in lengths of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. Each rod must be a different color. Represent the value of 1 with the rod that is 12 units long. Add and subtract fractions as joining and separating parts referring to the whole. Decompose a fraction into a sum of fractions with the same number in the denominator in more than one way. Record each decomposition by using an equation. Justify with your visual fraction model made of cubes. |
| Grade 5 CCSSM | Use of Minecraft |
| Analyze patterns and relations. | Build a triangle by beginning with a base of sixteen cubes (row 8). On the next row, decrease cubes by two, (row 7), and continue in this pattern until you have two cubes on top (row 1). Write an equation showing the relationship between the number of the row and the number of blocks on that row. Have students develop similar but original patterns and write as equations showing the relationship between the row number and the number of blocks. |
| Interpret multiplication as scaling (resizing). | Using 1 cube = 1 meter, re-create a model of a historical building or your school. |
| Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition. | Build towers (solid rectangles) by packing the cubes close together without gaps. Measure the volume in unit cubes. Apply the formula $V = l \times h \times w$. Recognize volume as additive. Have students find volumes of solid figures composed of two nonoverlapping right rectangular prisms formed by cubes by adding the volumes of the nonoverlapping parts. Also, counting the number of blocks that were dug out when making a $6 \times 6 \times 3$ cave can support concepts of volume and area. |

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Common Core State Standards Initiative (CCSSI). 2010. Common Core State Standards for Mathematics. Washington, DC: National Governors Association Center for Best

Practices and the Council of Chief State School Officers. http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf