Developing Mathematical Concepts Through Orientation and Mobility

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From the Editors: Keeping with a TNR tradition, we periodically include a legacy article that was previously published in AER's earlier journal, *RE:view*. For this issue of TNR, we have chosen an article that has become a favorite of many practioners and has frequently been referenced by our fellow professionals. In this reprint, author Derrick Smith illustrates how math concepts can be incorporated within and strengthened through Orientation and Mobility (O&M) instruction.

Author's Introduction to This Legacy Article

Even though I have been in the field for over 20 years and have published numerous articles and book chapters, this article is the one that people bring up to me the most. I wrote this article during my doctoral studies at Texas Tech University as I was completing my orientation and mobility coursework. As a secondary mathematics teacher, I noticed the many opportunities to infuse mathematics into O&M instruction and was encouraged to share my thoughts on the topic with the field.

When the article was written, the Common Core State Standards (CCSS) Mathematics (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2009) had not been published. Since its publication, there has been a fundamental shift in mathematics education that resulted in focusing more on authentic instruction. Within the CCSS, the "Mathematical Practices" outlined a stronger emphasis on how to best use mathematics as a tool for a successful and productive life.

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In reviewing the article through the current lens of mathematics instruction and O&M instruction, many of the concepts outlined in the article continue to be relevant. Within the O&M curriculum, O&M instructors have a vast array of opportunities to continue to make connections to basic and consumer math, measurement, and geometry. My primary amendment to these areas is that I would change "basic math" to "numeracy skills." Ensuring that all students have strong numeracy skills can be accomplished in all the ways mentioned within the original article. Numeracy—the ability to use mathematical information to make informed decisions—includes a vast array of "real-world" skills from basic operations to using fractions, decimals, and percentages, to using numerical data to make informed decisions. Ultimately, O&M provides a unique opportunity to take numeracy skills and place them in an authentic context.

The greatest impact on teaching mathematics within O&M is the increase of innovative technologies that can augment independent travel. When the article was written, smartphones were in their infancy with their major impacts to come. Now, individuals receiving O&M training tend to have a powerful computer in their hands and/or pocket. For example, these devices have an accessible scientific calculator that allows an individual to quickly compute the price of an item that is "on sale." The GPS system within the phone, possibly coupled with specific apps that were developed for individuals with visual impairments, can provide not only spatial and route information but can instantly provide data about weather over time, traffic patterns, distance traveled, and estimated time of arrival to destinations. Paired with a smartwatch, numerical data on distance traveled, health information, etc., can be collected for use. While technology has made the numerical analysis more efficient, individuals still need training on how to use the data effectively to travel independently.

In the end, any concept that uses spatial concepts (such as length or distance), time, and numeracy are clearly concepts that can be integrated into many O&M lessons. Lessons that infuse the Expanded Core Curriculum further expand the opportunities to utilize many numeracy and basic algebraic thinking skills. Algebraic thinking involves using numerical information to solve complex problems. Problem solving is a critical aspect of the O&M curriculum whether it uses mathematics, science, geography, English language arts, health, etc. The O&M instructor has a wonderful opportunity to make strong connections to academic content. This is often the most powerful way to ensure that students are prepared to be independent.

Original Article

The standards of the National Council for Teachers of Mathematics (NCTM; 2000) include the statement that "when students can connect mathematical ideas, their

understanding is deeper and more lasting" (p. 63). The NCTM encourages students to experience mathematics in multiple contexts, including science, history, physical education, business sciences, and agricultural sciences. All educators, including professionals such as orientation and mobility specialists who work with students who are visually impaired or blind, should hold to this standard. With a little effort, the field of orientation and mobility (O&M) can provide experiences that help students with visual impairments and blindness to develop the conceptual framework for understanding mathematics.

My review of the journal literature found little discussion of using O&M to reinforce and teach mathematical concepts. Rosenblatt (1994) reports on a case study in which she uses opportunities occurring during O&M lessons to teach basic consumer math skills such as counting money. This is a wonderful example of using an opportunity presented by O&M instruction, but it discusses only a simple connection. By examining classic O&M curriculum and texts (Blasch, Wiener, & Welsh, 1997; Hill & Ponder, 1976; Jacobson, 1993), one can identify many mathematical concepts that are reinforceable through O&M instruction.

Connections to Basic and Consumer Mathematics

Beginning with basic math skills such as counting and the use of operations (addition, subtractions, multiplication, and division), O&M activities can be used in the elementary years to introduce and strengthen many core concepts. As children mature, so do the O&M opportunities for exploring other mathematical topics. O&M activities can include consumer math skills such as counting money, measurement concepts, geometry, logic, problem solving, and basic algebra. The general education mathematics teacher and O&M specialist can work together to integrate their lessons so that students who have visual impairments can make connections in both settings. Students benefit from teacher collaboration that develops concepts and reinforces them in each environment.

O&M specialists often work in business settings with students who are visually impaired. As part of advanced O&M skill development, students may participate in lessons that incorporate both O&M and daily living skills (Jacobson, 1993), giving them natural opportunities to learn and use basic consumer math skills such as adding and subtracting currency in real-world situations. By allowing students to use mathematics in that way during an O&M lesson, the instructor allows them to connect mathematics and the world outside of school (NCTM, 2000).

Connections to Measurement

The ability to measure and understand time and distance affects how well a student who is blind or visually impaired can travel. Hill and Ponder (1976) stated that

"linear measurements are constant" and that "everything in the environment is measurable" (p. 8) and explained that understanding standard increments of measurement, being able to compare measurements, and applying linear measurement are imperative for an individual to be an independent traveler. Jacobson (1993) contended that the "concepts of time play an integral part in one's ability to understand the environment" (p. 29).

The NCTM standards expect students, even as early as kindergarten, to understand and be able to use concepts of measurement. Classroom teachers use model clocks and work sheets to teach time; by working word problems, students determine the number of hours needed to fly between Los Angeles and New York City. Through activities with rulers and yardsticks, students "discover" the concept of distance. However, students who cannot observe the movement of a clock or view an object of a given size may have difficulty grasping concepts of time and measurement and have few opportunities to develop these concepts, either academically or practically (Kapperman, Heinze, & Sticken, 2000). Thus, an opportunity opens for the O&M instructor to help develop these concepts (Fazzi & Petersmeyer, 2001).

The prospect of connecting concepts of measurement to O&M lessons is boundless. For example, to plan a travel route, students need to understand the distance from one point to another and then be able to determine how much time the trip will take. In that first planning phase, students determine distance by comparing it with their current conceptual knowledge of length. O&M specialists teach the concept of "time-distance estimation" so that the student can determine distance to a location. The student estimates, either formally or informally, the travel time by using a simple formula of $d = rt$ (distance equals speed multiplied by time). After planning, the student must then apply their mathematics finding and be ready to change them if, for example, the distance is too great to travel in the available time. That step reinforces operational mathematics, estimation, geometric concepts of distance, and the application of a mathematical formula in a simple lesson in independent route development.

Connections to Geometry

Geometry literally means "to measure the earth"; thus, the concepts found in this subject are applicable to many real-world situations. O&M uses several geometric terms—parallel, perpendicular, point, line, rectangle, and curve, to name just a few.

Jacobson (1993) states that "individuals with visual impairments must learn to walk in straight lines to understand the true relationships of objects in the space about them" (p. 30) and that the O&M student must first understand the concept of

Table. Connecting Mathematics and Orientation and Mobility.

Mathematical concept	Orientation and mobility connection
Linear measurement Concept development (e.g. length, width) Time/distance estimation Distance formulas	Develop measurement by learning distances through walking differing lengths. Provide opportunities for students to estimate distance through route travel and planning. Real-world application of distance equals time times rate (d = rt).
Definition of geometric terms Points Line segments	Use fixed positions in space, such as landmarks, to explain points. Explain line segments by using travel paths.
Positional terms (e.g. above, below, under)	Introduce and use these terms throughout instruction
Angles	Turns of 45°, 90°, and 180° are commonly used in travel
Polygons	Explore squares, rectangles, and circles in travel, such as around city blocks or around parks. Introduce other polygons, such as pentagons, hexagons, and octagons by exploring traffic signs.
Parallel lines	Explore this concept through shorelining and parallel traffic.
Perpendicular lines	Demonstrate this concept by crossing intersections of sidewalks, hallways, and streets.
Consumer math skills Counting Money Skills	Various situations such as counting doors, steps, or streets provide counting opportunities. Business (or semi-business) settings provide opportunities to expand money skills
Perimeter	Explore this concept during perimeter familiarization of a room or while traveling around a city block.
Area	Explore this concept during familiarization (or exploration) of any area (a desk, table, or room) using the grid pattern.

a "point" before moving onto the more complex concepts such as lines and planes. The O&M specialists must develop the abstract concept of points as fixed positions in space so that students will understand their position in the environment. Once students grasp this concept, then, as they move forward through space, the

instructor can apply the idea of a line being a connection that ties points together. Lines are points arranged in a row, whereas points arranged in an arc shape create a curve (Jacobson). The idea of a line leads to the concept of a plane, by which students develop an understanding of such three-dimensional terms as *above*, *under,* and *over*.

O&M instruction can bolster more advanced geometry concepts, such as angles, parallel, perpendicular, and shape. Through "squaring-off" or making 90-degree turns when engaged in street-crossing activities, students learn basic concepts of angles (Jacobson, 1993). Verbally connecting these activities to geometry aids the student's overall understanding of angles. Learning basic shapes (e.g., octagons, rectangles, and squares) enables a student with low vision to recognize traffic signs: the octagonal stop sign, the triangular school sign, and the many other signs that are square or rectangular. While students are learning procedures to become familiar with a room, they can learn the concepts of perimeter and area (Jacobson). Perimeter familiarization is a preliminary means of exploring a room and one by which students can develop the concept of traveling around a shaped area. The use of the grid pattern in room familiarization is an opportunity to integrate area into the O&M lesson.

O&M instruction uses the terms *parallel* and *perpendicular* in indoor and in outdoor travel. Students need to conceptualize the idea that the street with cars is running parallel, or beside, them as they travel down the sidewalk (Jacobson, 1993). Traveling down a sidewalk, students will come to a street that is perpendicular to the sidewalk, requiring them to cross that street where it intersects the sidewalk. The parallel traffic indicates to them when it is clear to cross the street. The student is developing a mental picture of the terms *parallel*, *perpendicular,* and *intersects* through real-world applications. Students will be able to conceptualize the geometry classroom discussion from their O&M experiences.

Conclusion

Although O&M develops many pure mathematical concepts, it also cultivates skills that are valuable to the student in many contexts in addition to mathematics. O&M provides an abundance of situations that require students to problem solve; the logic taught in the mathematics classroom is vital to the development of problem-solving ability. Often O&M instructors use tactile models to teach environmental arrangement or travel routes. These orientation aids are intended to facilitate the learning of spatial concepts (Bentzen, 1997), a skill critically needed when using tactile graphics in the mathematics classroom (Kapperman, et al., 2000).

The connections between mathematics and O&M are apparent and offer challenges for O&M instructors to find ways to use that connection to encourage the conceptual development of mathematics ideas. Many concepts needed for independent travel can be taught and developed in the mathematics classroom. At the same time, many of the of the abstract concepts derived in mathematics classrooms can be placed in a real-world context through O&M instruction. See Appendix Table A1 for a summary of how the two subjects can be connected. Collaboration between the two educators—mathematics teachers and O&M instructors—will greatly assist students who are visually impaired or blind to become successful and independent individuals.

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