MY FAVORITE lesson

Michael Todd Edwards and James Quinlan

Virtual Miniature Golf

Current standards place significant emphasis on transformations in school geometry: "Fundamental are the rigid motions: translations, rotations, reflections, and combinations of these," and "dynamic geometry environments provide students with experimental and modeling tools that allow them to investigate geometric phenomena" (CCSSI, 2010, p. 74). With these aims in mind, we share a favorite classroom activity—virtual miniature golf. Building on the work of Coxford and Usiskin (1991) and Powell et al. (1994), this activity provides geometry students with a real-world context for exploring reflection and reflection composition in technology-rich settings.

Step 1. Students design individual miniature golf greens using GeoGebra dynamic mathematics software. Initial construction of each green requires three components: (1) a polygon to represent the boundary of the green; (2) a point, *S*, to represent the starting point for a golf ball; and (3) a small circle, *T*, to represent the target (see **fig. 1a**).

Step 2. Students construct a hole-in-one path using GeoGebra (see **fig. 1b**). Rather than joining *S* to *T* directly using one line segment, students must construct a path that requires one or more bounces off boundary walls. This constraint requires students to consider properties of angles of incidence and composition of reflection while encouraging the creation of more challenging golf holes. The target, *T*, is reflected (first to locate point *T′* and then *T″*) over boundary walls to be hit in reverse order. Students use angle measurement tools to verify that paths respect the laws of physics—namely, that angles of incidence and reflection are congruent for each wall bounce (see **fig. 1b**).

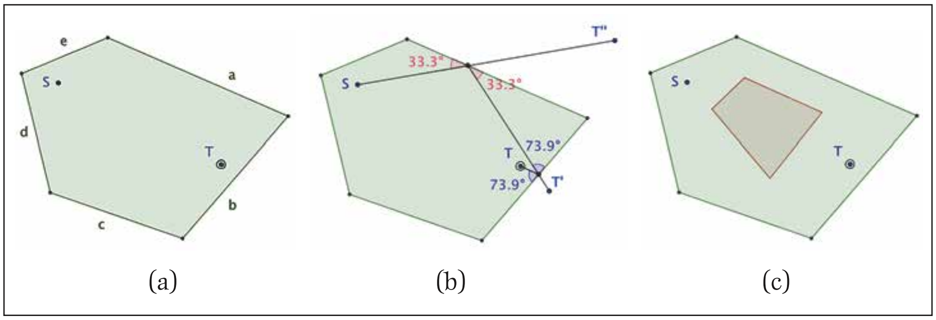

Fig. 1 Construction occurs in stages: an initial polygon (**a**); reflected segments (**b**); and imposed hazards (**c**).

Step 3. After students construct hole-in-one paths, they refine their constructions. Students adjust boundaries, add water hazards and sand traps, and hide solution paths (see **fig. 1c**).

We give students a printed packet of all completed holes. As they construct hole-in-one paths of classmates' holes using compasses, protractors, and GeoReflectors™, students' understanding of reflections and their compositions is reinforced. We overlay write-on transparencies on top of their work to quickly assess their solutions for mathematical accuracy.

Virtual miniature golf provides students with opportunities to design and solve their own problems using pencil-and-paper tools as well as dynamic mathematics software.

This lesson provides a fun and creative way to explore composition of reflections and angle-measure properties in a real-world, problem-solving context.

The Back Page provides a forum for readers to share a favorite lesson, not exceeding 600 words. Lessons should be submitted to mt.msubmit.net.

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Coxford, Arthur F., and Zalman Usiskin. 1991. *Geometry*. University of Chicago School Mathematics Project (UCSMP). Glendale, IL: Scott Foresman.

Powell, Nancy Norem, Mark Anderson, and Stanley Winterroth. 1994. "Reflections on Miniature Golf." *Mathematics Teacher*: 87 (7): 490–95.


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For a GeoGebra file for Virtual Miniature Golf, go to **www.nctm.org.mt**. To access the sketch directly from GeoGebraTube, go to **http://tube.geogebra.org/student/m244509**.