Architecting the Next Generation of Young Professionals

The Build San Francisco model turns students into aspiring designers and architects.

The Build San Francisco Institute (Build SF) is an academic program created by the Architectural Foundation of San Francisco. It is designed to help high school students earn up to fifteen hours of credit learning design, engineering, and architecture skills.

The curriculum download is part of our larger New Day for Learning series, which focuses on the growing national movement to redefine how, when, and where students learn, taking an in-depth look at an exemplary full-time-learning program, including comprehensive articles, sample lessons, and video interviews with program participants. This additional information is available through Edutopia at edutopia.org/new-day-for-learning-two. These lesson plans and curriculum materials are provided by Build SF.

What Build SF Is About and Why We Picked It

More than thirty local firms sponsor Build SF, an academic program that was created in 1993 by the Architectural Foundation of San Francisco. Each semester, every Build SF student gets the chance to work for a leading local firm, choosing from fields including architecture, engineering, interior design, landscape architecture, historic preservation, contracting, construction, and others. Build SF students develop real-world communication and work skills by solving real problems and by mentoring with local design and civic organizations.

The Build SF program invests in components we've found critical for long-term student achievement—project learning through class curriculum and community interaction with mentors. Of the many academically rigorous projects that Build SF offers in urban sociology and civic and architectural design, we've chosen the golf-course project as a fun and manageable way to emphasize math, design, and twenty-first-century learning skills through project learning. Through third-party assessment, Build SF has developed a system to measure students' progress in each of several key learning-skills areas.

Who It's Best For

» Grade 8-12 teachers, especially math, art, or design educators

» Principals or administrators who want to initiate a similar model

» Grade 8-12 students, but much of it is adaptable to other grade levels

How to Use the Material

» The materials can be viewed in any order. Everything is customizable to your teaching style and academic requirements.

» Through the six-part lesson plan, students design, present, and build miniature-golf-course holes in accordance with design and math standards. Reserve about four to six hours for each lesson, which can be extended across a semester or completed over several weeks.

What It's Designed to Teach

» Math skills, such as measurement, estimation, and geometry.

» Art and design skills, such as visualization, orthographic drawing, three-point perspective, composition, and layout.

» Twenty-first-century learning skills, such as oral communication, teamwork, problem solving, and professionalism.

» Technological skills using 3-D rendering software.

Support for coverage of learning beyond the classroom is provided in part by the Charles Stewart Mott Foundation.

Lesson 1: How to Draw in 2-D and 3-D

Teach your students how to sketch polygons and objects in perspective.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

Math and art comingle in this first lesson, which gets students to think about shapes and objects from different perspectives. The information here prepares students for sketching and graphically rendering their holes in future lessons.

Before beginning this lesson, define the project's goals. Will students build a playable course from their designs? If so, when and where? Or will students just learn about some basic techniques? Be sure to discuss with students about the project's agenda, keeping an open communication channel throughout the curriculum.

Engaging Students

Get your students interested in the lesson by asking them the following questions:

- Ask for definitions and examples of 2-D, 3-D, orthographic drawing, polygons, and perspective. (See the glossary for definitions.)
- Ask them to find specific polygons in the classroom or in their lives. For example, a stop sign or the chalkboard.
- Ask for examples of movie studios that make films primarily in 2-D (Disney's older films) and primarily in 3-D (Pixar).

Project Application: 2-D Drawing

Ask students to draw a rectangle and another polygon of their choice in 2-D – first in free-hand and then using a ruler and graph paper. Here are tips for practicing certain skills:

- To practice perimeter and area, assign students lengths and widths for the rectangle.
- To practice calculation, try changing the measurements.
- To practice estimation, convert from standard measurement to metric measurement and back again.
- To help struggling students, have them practice drawing a polygon until they're more comfortable using a pencil, a ruler, and graph paper.

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- To define and recognize a variety of polygon
- To represent the same shape in 2-D and 3-D in order to practice three-point perspective drawing

MATERIALS

- graph paper
- protractors
- pens and pencils
- rulers
- objects or graphics representing different polygons

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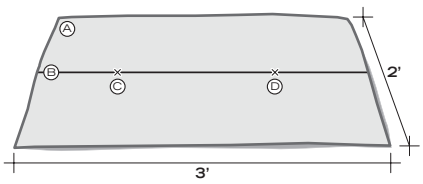
Project Application: 3-D Perspective Drawing

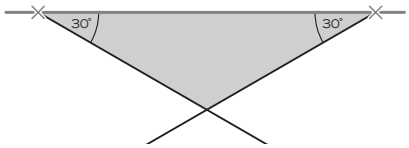
Perspective drawing requires finding the vanishing point and drawing rays that extend from that point. Get your students to draw a 3-D rectangle in perspective by asking them to follow these steps:

1. Using a piece of 2- by 3-foot blank paper or graph paper (A), oriented horizontally (landscape style), draw a line that bisects the paper (B). This is the horizon line.
2. Make a small "x" on the left edge (C) and on the right edge (D) of the horizon line. These are the vanishing points, the two points to which all visual lines lead.
3. Use a protractor (or estimate) to draw a 30-degree angle at each vanishing point, extending the rays of the angle toward the bottom of the paper until they meet to create a large isosceles triangle.
4. Form the base of a 3-D rectangle by drawing a dark, 1.75-inch horizontal line from the bottom point of the triangle to the left. Then draw a dark, one-inch line from the bottom point of the triangle to the right.
5. Draw a 1-inch vertical line from the bottom point of the triangle up.
6. Draw a 2-inch line extending from the top of the vertical line toward the left vanishing point (the first "x"), but the line should not connect to the vanishing point. Repeat for the right vanishing point.
7. Draw a vertical line that connects the left edge of the bottom line (the base of the rectangle) to the left edge of new line you created in step 7. Repeat for the right edge.
8. Complete the 3-D rectangle by drawing a line from the top of the right vertical line to the left vanishing point. Then repeat the process by connecting the left vertical line to the right vanishing point.

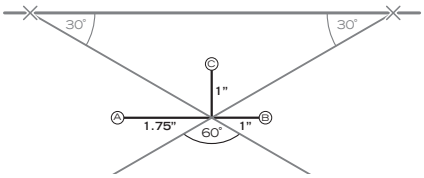
STEP 1 + 2



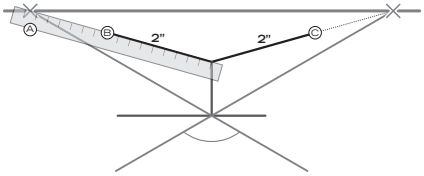
STEP 3



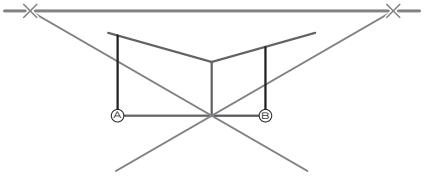
STEP 4 + 5



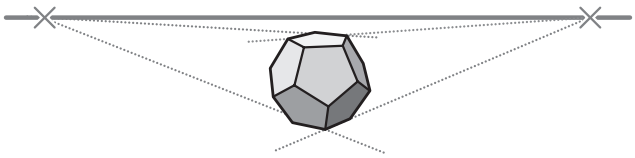
STEP 6



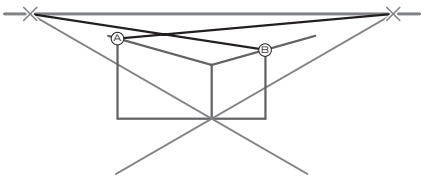
STEP 7



COMPLEX POLYGON WITH 2-POINT PERSPECTIVE



STEP 8



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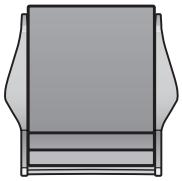
Project Application: Introduction to Orthography

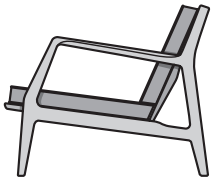
Help your students visualize objects from the three views of orthographic drawings: plan, side, and front. You will further develop orthographic drawings in Lesson 4. Here are some pointers to whet your students' orthographic appetite:

» Ask students how many ways they think they can draw their polygon.

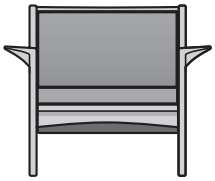
» Form groups, and ask each group to look at the same complex item (a chair, a bike, or a backpack) from a different viewpoint–one group from top down (the **plan** view), another group from the side (the **side** view), and another group in front of the object (the **front** view). Discuss what students do and don't see from each angle.



PLAN



SIDE



FRONT

» Explain what each different view means and its relationship to orthographic drawing.

» Ask students why architects create multiple illustrations of a building in different perspectives. How do multiple designs help in planning the building? Why is this important to investors and in the construction process?

Student Assessment

At the end of this lesson, you should have a good idea of each student's understanding and skill level with polygons, drawing in perspective, and the other concepts covered. Here are some guiding points to help assess each student.

The student's mastery of the subject matter is

» **Excellent:** Students can differentiate between true polygons and other shapes and represent them accurately (2-D and 3-D are correctly drawn) and with a sense of composition.

» **Good:** Students can differentiate between true polygons and other shapes and represent them accurately.

» **Fair:** Students often spot polygons but mislabel some shapes; drawings are inaccurate or lack the depth of three dimensions.

» **Poor:** Students do not differentiate between polygons and other shapes; 3-D drawings look 2-D.

RELATED TERMS

» **Polygon:** A closed shape with three or more sides, such as a triangle, square, or pentagon.

» **2-D:** A description of an object that has only two dimensions, usually just length and width.

» **3-D:** A description of an object that has three dimensions, usually length, width, and height.

» **Orthographic drawings:** A series of related drawings from multiple viewpoints (usually top, side, and front) that show a three-dimensional object in two dimensions.

» **Perspective:** A method of seeing and drawing that allows artists to represent three-dimensional scenes in two dimensions.

KEY POINTS

Review the following concepts before beginning this lesson:

» Geometry

» Orthography

» Perspective drawing

Support for coverage of learning beyond the classroom is provided in part by the Charles Stewart Mott Foundation.

Lesson 2: Conceptualizing the Golf-Hole Design

Fostering creativity through brainstorming and sketching sessions.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

In the last lesson, you prepped your students about designing a hole for a miniature-golf course. Here, students brainstorm ideas for their holes based on the specific parameters you set.

Engaging Students

Get your students interested in the lesson by asking them the following questions:

- What's the purpose of sports?
- What are the differences between ball-based sports and other sports?
- What are the differences between small-ball sports (baseball, tennis, golf, table tennis) and large-ball sports (basketball, volleyball, football)?
- Why participate in sports? Why try new sports?
- What sports are fun for you? For your parents? For your grandparents?
- Who has played miniature golf or golf before? What are the similarities and differences? What sports are similar to golf?
- What resources are good for learning about miniature golf? (Ask students to check out Web sites and report back on their findings.)

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- Inform students
- Overcome possible biases
- Foster creativity

MATERIALS

- graph paper
- examples of golf holes
- golf putter
- golf balls
- Styrofoam cups
- cardboard
- balsa
- other materials for building ramps and obstacles

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Project Application: Define and Brainstorm

Define the parameters of the project, and get your students to brainstorm ideas for the possible layout and design of their golf holes. Use online resources and examples to drive student creativity.

STEP 1: DEFINE PARAMETERS OF THE PROJECT.

Before this lesson, come up with specific goals, design requirements, and a timeline for creating the golf holes. Post them in the room or ask your students to write them down. Here's an example, taken from the original project.

Project Goal

To construct a playable nine-hole golf course based on the student's design and presentation.

Design Specifications

- Each hole needs to meet regulation cup size, which by rule must have a diameter of 108 mm (4.25 inches) and a depth of at least 100 mm (3.94 inches).
- The putting area for the hole must fall within the assigned area (20 by 20 feet)
- Students should design the hole so that an average-size person can play it.
- Each hole should have at least three hazards.
- All designs must be original!

Timeline

- Week 1: Brainstorm and sketch
- Week 2: Presentation boards
- Week 3: 3-D software design and ball animation
- Week 4: Oral presentations and peer critiques
- Week 5: Final presentation and project submission

STEP 2: BRAINSTORM IDEAS FOR THE HOLE AND COURSE DESIGN.

Open up a discussion to help students think about their individual golf-hole designs. Here are some ways to get the creative juices flowing:

1. Brainstorm about the design: the player, ball, tee, putter, course, hazards, hole, green, border, and decorations and props
2. Brainstorm possible themes:
   - No theme/neutral
   - Historical: the American Revolution, the Wild West or frontier, industrialization
   - Geographical: Central America, Sub-Saharan Africa, Eastern Europe, Japan
   - Cultural: famous art, inventions, political movements, the green/environmental movement
   - Animal: dinosaur, domesticated animals, local fauna
   - Current Trends or Media: technology, science fiction or fantasy, action/adventure
3. Brainstorm possible hazards:
   - Dips, bumps, blocks, ramps, angles
4. Brainstorm about possible shapes:
   - Lines, curves, right angles, organic, figurative
5. Check out Web sites and other resources for ideas or bring in models or examples of designs.

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Project Application: Define and Brainstorm (continued)

STEP 3: START SKETCHING.

Ask your students to start sketching a hole based on the parameters you've set and their favorite ideas. Build on the last lesson by encouraging students to draw in perspective.

Student Assessment

At the end of this lesson, you should have a good idea of each student's verbal, creative, reasoning, teamwork, and drawing abilities. Here are some guiding points to help you assess each student.

The student's mastery of the subject matter is

- **Excellent:** Students have multiple ideas they can verbalize clearly. Students sketch several ideas, and the ideas show originality, complexity, or use of multiple influences.
- **Good:** Students have ideas they can verbalize clearly. Students sketch more than one idea, and the ideas show thought.
- **Fair:** Students participate in the brainstorming, but may not do so clearly or they may repeat others' ideas. Students sketch one idea or multiple ideas, but go for the easy solution. The ideas mirror expected patterns or have no complexity.
- **Poor:** Students fail to participate in the brainstorming session. Students draw, but don't take the assignment seriously, or they miss essential items (such as the hole and hazards).

Links to Links

Resources for more golf-related information:

- **ocf.berkeley.edu/~haeber/creations/minigolf.html**: "Simply Putt: Mini-Golf Is an Art Form"–a historical and aesthetic look at miniature golf
- **minigolfenthusiast.blogspot.com**: The Mini Golf Enthusiast–a blog about miniature-golf topics
- **prominigolf.com**: Professional Miniature Golf Association of America–the PGA of miniature golf
- **access-board.gov/recreation/guides/min-golf.htm**: Miniature Golf Accessibility Guidelines–discusses accessibility-design issues with an eye to the Federal Americans with Disabilities Act
- **miniaturegolfcourses.net**: MiniatureGolfCourses.net–a directory of miniature-golf courses across the United States
- **tigerwoodsfoundation.org**: The Tiger Woods Foundation–offers scholarships, grants, and activities for youth

KEY POINTS

Set up a miniature-golf hole in your room to help students understand what miniature golf is, how to play it, and what the hole entails. Create the hole with fake green for the path (if available), a ramp or other objects for obstacles, and a Styrofoam cup for the hole.

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Lesson 3: How to Build Golf Holes to Scale

Practice teamwork skills and estimation by having students lay out a life-size replica of their golf holes.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

Before starting this lesson, be sure that each student has sketched out a viable hole for a miniature-golf course. In this lesson, students will pair up and assemble one or more life-size golf holes based on their sketches.

Engaging Students

Get your students interested in the lesson by asking them

- To look at others students' sketches and find one complimentary thing to say
- To predict the challenges and differences between having sketched a hole on paper and laying one out to scale
- To brainstorm what makes for good teamwork, such as clear goals, clear communication, flexibility, compromise, and participation

Project Application: Laying the Green

Ask students to create a life-size replication of each hole based on their sketches. Students will use tape to lay out the course on the classroom floor or outside. Before beginning, ask each student to choose his or her favorite rough sketch, and have them redraw it for clarity if necessary.

Have your students lay the green by asking them to follow these steps:

1. Pair up with another student.
2. Estimate how many inches, feet, centimeters, or meters each segment of the course will be based on each component of the hole. For example, they should measure the hole size in inches or centimeters and the green in meters or feet.
3. Discuss one or more of the following:
   - Course plan: Which partner's hole gets laid out first and where
   - Material management: Who manages which materials
   - Challenges: What the team will do if it runs out of tape, room, or time
4. Use tape to lay out the course based on the predetermined design specifications. (See lesson 2 for more details.)

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- Practice teamwork, especially communication
- Overcome possible biases
- Use estimation and scale
- Use critical-thinking skills

MATERIALS

- Tape (duct, carpenter's, or other tape depending on your floor's surface)
- Nerf balls
- yardsticks
- rulers
- measuring devices

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Project Application: Laying the Green (continued)

5. Make comparisons between estimations and actual measurements. Help students make practical estimations by using their
   - » Hands as a small ruler: Ask students to stretch out their hands and measure the length from the tip of the thumb to the tip of the pinky. (FIG. A)
   - » Wingspan as a larger ruler: Ask students to spread out their arms and measure from the tip of the longest finger on one hand to the tip of the longest finger on the other hand. (FIG. B)
6. Play the holes with Nerf balls and yard sticks (or other readily available materials) and think about the pros and cons of each hole.
7. Record feedback about each hole from the group. Discuss the strengths and weaknesses by looking at the following features:
   - » Length: Is there enough room for the golf ball to gain momentum?
   - » Turns: If sharp, are there walls or banks for the ball to bounce off of?
   - » Ramps: Is the angle too sharp to allow for the ball to roll up?
   - » Hazards: Are there too many, creating player frustration, or are there not enough, resulting in a boring hole?
   - » Hole: Is the size appropriate to fit a golf ball? Is it placed properly?
   - » Spatial dimensions: Are there places for players to stand throughout the hole? Does it feel crowded?
   - » Overall fun: Is the course fun and engaging?
8. Use critiques from the previous step to help refine each hole. Ask students to improve their sketches based on student feedback.

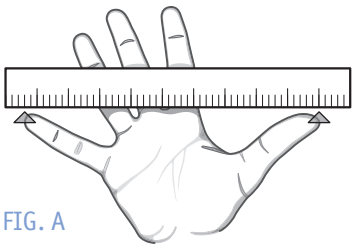

FIG. A

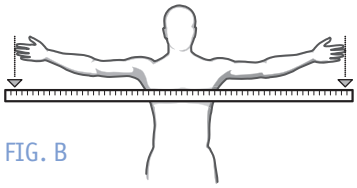

FIG. B

Student Assessment

At the end of this lesson, you should have a good idea of each student's ability to communicate effectively, work in teams, think critically, use estimates, and understand the other concepts covered. The students' mastery of the subject matter is

- » **Excellent:** Students strike a balance in listening, talking, and doing. The students estimate distances well, creating a clean working floor model. Students provide and record a critique that shows awareness of geometry and practicality.
- » **Good:** Students listen, talk, and do. Students estimate distances, creating a working floor model. Students provide and record a critique.
- » **Fair:** Students do two of the three: listen, talk, do. Students fail to estimate distances or do so poorly. Students finish their floor model, but it is unplayable or messy. Students critique only the obvious.
- » **Poor:** Students do not focus. Students play with the tape or use it inappropriately. Students do not take the critique seriously.

KEY POINTS

Ask your school's custodian about the proper tape to use on the floor. Some tape can be difficult to clean up depending on the floor's surface. Duct tape is especially troublesome on slick surfaces.

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Lesson 4: How to Make Blueprints on Presentation Boards

Revisit orthographic drawings by teaching students how to create and present plans for their golf holes.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

This lesson looks at topics covered in previous lessons–perspective and orthographic drawings, and applies them to the project.

Engaging Students

Get your students interested in the lesson by doing the following:

- Ask them about what they've learned so far, such as perspective drawing and other key concepts.
- Have them demonstrate specific skills or lessons on the chalkboard. For example, ask your students to draw a golf hole in 3-D perspective.

Project Application: Creating Presentation Boards

Teach students how to create three or more different perspectives of their holes on presentation boards. Review some orthographic and perspective-drawing techniques first, then dig into the drawings.

Follow these steps to get your students underway:

1. Review orthographic drawings and plan, side, and front views. (See Lesson 1.) Ask students to practice drawing their holes in these three views on graph paper.
2. Review some important geometry techniques and definitions so that students can label their drawings correctly. For example, go over perimeters, angles, and area.
3. Discuss the characteristics of presentation boards. Presentation boards can include
   - A brief, informative title in large letters, if handwritten, or in a large font (such as 24-point) if done on a computer
   - The same object (in this case, the golf hole) in plan, front, and side views, with each view labeled
   - A border around each view
   - Measurements of each part of the hole as they'd actually appear
   - A sense of composition (balance and the effective use of white space) and color/contrast (for advanced students)

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- Incorporate feedback
- Use geometry and critical-thinking skills to design playable holes
- Use orthographic drawings to represent the design

MATERIALS

- presentation boards (11 x 14 inches or 20 x 30 inches)
- rulers
- graph paper
- measuring sticks
- pens and pencils

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Project Application: Creating Presentation Boards (continued)

Have students design and illustrate presentation boards. Some students might want to sketch board components on scratch paper first before transferring the sketch to the board.

Ask students to review each other's drawings and provide feedback based on the following questions:

- What do you like most about the design?
- Is the model well built? Is the design clear and realistic?
- Is the hole challenging enough? Too challenging? Would you have fun playing the hole?
- Do you think it is possible to build this hole and play it in the designated area (such as in the gymnasium or classroom)?
- What areas do you think need improvement? You can base your suggestions on the questions above.
- Ask students to incorporate any suggestions by redesigning their boards or by integrating critiques into the next stage of the lesson.

Student Assessment

At the end of this lesson, you should have a good idea of each student's ability to create orthographic drawings, apply geometry skills, and understand the other concepts covered.

Here are some guiding points to help you assess each student.
The student's mastery of the subject matter is

- **Excellent:** Students use balanced compositions to present three views of their hole. They've labeled each hole with accurate measurements, and the design reveals an awareness of its real-world application and original thinking via its design or theme. The board is clean, neat, and well labeled.
- **Good:** Students present three views of their hole. They've labeled each hole with accurate measurements, and the design reveals an awareness of its real-world application or shows original thinking via its design or theme. They've labeled the board.
- **Fair:** Students present three views of their hole. They've labeled each hole with measurements, and the design reveals some awareness of previous discussions, but it is clichéd or very simple. They've labeled the board, but not neatly or accurately (e.g., it has spelling errors).
- **Poor:** Students fail to present three views of their hole. They have not labeled each hole with measurements, and the design is not workable or is especially messy. They haven't labeled the board or it's bent, stained, or otherwise damaged.

KEY POINTS

Break this lesson up into different working sessions in which students can develop and improve their boards. Encourage students to incorporate feedback into every step of the process.

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Rubric for Assessing Presentation Drawing

STUDENT NAME _____ **DATE** _____

CATEGORY	EXCELLENT	GOOD	PROFICIENT	NEEDS IMPROVEMENT
CREATIVITY 15 points	Several of the graphics or objects, including title, used in the visual reflect an exceptional degree of student creativity in their creation and/or display. Graphics are in color.	One or two of the graphics or objects used in the visual reflect student creativity in their creation and/or display. Some are in color.	Graphics hardly creative; show little effort. Black and white graphics.	The student put in no effort.
ATTENTION TO THEME 15 points	Every item in the visual is related to the assigned theme. For most items, the relationship is clear without explanation. All information is precise.	Most items in the visual are related to the assigned theme. For many of the items, the relationship is clear without explanation. Information is mostly accurate.	Few items in the visual are related to the assigned theme. Information is random or vague.	Difficult to understand how items relate to the assigned theme. Information is inaccurate.
VIEW ANGLES 15 points	The course is displayed from multiple views of reference, including top view and at least two perspective and/or side views. All design details are clear without explanation.	The drawing has at least two viewing angles that display the design. Most of the design is clear without explanation.	The drawing has only one viewing angle. The design details are unclear and require explanation.	Drawing does not include details of design and is unclear.
NUMBER OF ITEMS 5 points	The visual includes several interesting items, each different.	The visual includes a few different items that are mostly interesting.	The visual includes a few different items that are not very interesting.	The visual is not interesting.

TOTAL POINTS _____

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Lesson 5: Using 3-D Software to Render Golf-Hole Designs

Teach students how to turn their golf-hole designs into cool graphics and animations.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

This lesson takes all the concepts from previous lessons to the next level. Here, students get to show off their stuff using 3-D-modeling software. First, demo the software to the class. Then give students free reign to render their designs digitally. You might want to extend this lesson over several class days during which students can work on their design. Students will present their final design to a group of people, so encourage students to knock out a polished product.

Engaging Students

Get your students interested in the lesson by asking them

- If they've ever used a 3-D program (assume many have not), and what they use the program for
- What they know about using computer programs. For example, what are computer programs designed to do? Explain the universal components found in most programs, including the program interface, tools, and applications.
- Who might use 3-D programs (e.g., animators, film artists, medical illustrators, architects, interior designers) and for what reason

Project Application: Using 3-D-Modeling Software

You don't need to be an expert in graphics or 3-D-modeling software to help students use the application. All it really takes is a little playing around with the interface and tools to get comfortable with it. Most software programs come with free help tutorials. (See the "Related Resources" sidebar.) Refer to the tutorials when in doubt. Then explain the main tools and techniques to students and let them experiment with the software. Nowadays, kids usually pick up on this information quickly and don't need much guidance.

Regardless of the program, here are some steps to help teach 3-D and animation software:

1. Explain what 3-D software does.
2. Show a video or graphic made from the software.
3. If available, show a how-to movie about the software (often a part of the software's Help menu).
4. Explain important parts of the software's interface, such as the pointer, move, zoom, pan, and animation tools.
5. Demonstrate how to draw a cylinder or a square. Ask students to do the same.

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- Learn 3-D-modeling software or become more proficient using it

MATERIALS

- 3-D-modeling software or graphics-arts software, such as Autodesk 3ds Max, Google SketchUp (free), or Autodesk AutoCAD
- computers to demo and work on

KEY POINTS

Are some students picking up software skills more quickly than others? Ask them to help the students who are having trouble.

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Project Application: Using 3-D Modeling Software (continued)

6. Present a complex graphic in orthographic views. For example, most graphic programs show the front, side, plan (or top), and perspective views. What can you do in each view that you can't in the others? Often, the front, side, and plan views provide accurate measurements, while the perspective view gives a good lay of the land.
7. Ask students to draw shapes using Boolean logic (the algebra that allows the program to create 3-D graphics). Encourage students to name and save all objects they create.
8. Demo how to integrate animation into the computer program.
9. Let students experiment with the program. Then ask them to begin designing their holes using exact measurements and logic. In addition, they should render a movie that includes the path of the ball from starting position into the hole. Emphasize the following areas when working:
   - » Light
   - » Composition and color
   - » Animation speed
   - » Shapes
   - » Realism
   - » Project requirements (measurements, etc.)
10. Ask students to review and critique each other's designs throughout the assignment using the questions from the previous lesson:
    - » What do you like most about the design?
    - » Is the model well built? Is the design clear and realistic?
    - » Is the hole challenging enough? Too challenging? Would you have fun playing the hole?
    - » Do you think it is possible to build this hole and play it in the designated area (such as in the gymnasium or classroom)?
    - » What areas do you think need improvement? You can base your suggestions on the questions above.
11. As with other lessons, ask students to incorporate feedback into their final product.

Student Assessment

At the end of this lesson, you should have a good idea of each student's ability to use graphics software, process and apply new skills, and understand Boolean logic. Here are some guiding points to help assess each student.

The student's mastery of the subject matter is:

- » **Excellent:** Students have become familiar with the software. They understand and use Boolean shapes, accurately represent their golf-hole design in 3D, and use the animation features to animate a ball rolling through the course.
- » **Good:** Students have become familiar with the software. They understand and use Boolean shapes and accurately represent their golf-hole design in 3-D.
- » **Fair:** Students have become familiar with the software. They attempt to use Boolean shapes, but do not fully understand them. Students represent their golf-hole design in 3-D, but there are errors in scale or composition. Students do not complete the illustration.
- » **Poor:** Students fail to become familiar with the software and struggle to understand the interface.

RELATED RESOURCES

For this lesson you'll need 3-D modeling software. Here are two applications you can use:

AUTODESK 3DS MAX

usa.autodesk.com: Autodesk 3ds Max is an industry-standard program that design professionals commonly use for 3-D modeling. Architects use Max to create realistic models of their designs, which they can move around in space and test for structural viability.

GOOGLE SKETCHUP

sketchup.google.com: SketchUp allows you to create, modify, and share 3-D models for free. The software is compatible with Mac or PC operating systems, and students can use it at home and in the classroom.

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Rubric for Assessing Design in 3-D Modeling Software

STUDENT NAME _____ **DATE** _____

CATEGORY	EXCELLENT	GOOD	PROFICIENT	NEEDS IMPROVEMENT
ORIGINALITY 10 points	Product shows a large amount of original thought. Ideas are creative and inventive.	Product shows some original thought. Work shows new ideas and insights.	Uses other people's ideas (giving them credit), but there is little evidence of original thinking.	Uses other people's ideas, and does not show original concept.
OBJECTS IN PLACE 10 points	Project has all prescribed elements in place.	Project has most prescribed elements in place.	Project has some prescribed elements in place.	Many elements are lacking.
LIGHTING 10 points	Project makes use of light and shadow for dramatic or artistic effect.	Project uses light and shadow in appropriate angles and directions.	Project uses light to provide enhanced views of objects.	Lighting is random or misplaced. Objects are obscure or overlit.
MATERIALS 10 points	Project uses materials for artistic effect as well as realism.	Project uses materials to achieve realism.	Project makes use of standard materials.	Project uses no materials and relies on flat shading.
COMPOSITION 10 points	Objects achieve dramatic and artistic realism through placement as a total composition.	One or more objects dominate the composition.	Objects are clearly separated and present in view.	Some objects are obscured by others or are out of view.
COLOR CHOICE 10 points	Colors provide dramatic effect or realism.	Colors are appropriate to the mood and effect demanded by the scene.	Project makes use of color to vary the scene.	Colors seem random or they clash.
CAMERA PLACEMENT 10 points	Camera placement provides a dramatic angle and artistic view of the scene.	Camera placement is dramatic or artistic, but not both.	Camera placement provides a complete view of the scene.	Camera does not provide complete or accurate view of the scene.

TOTAL POINTS _____

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Lesson 6: Presenting and Playing the Hole

Guide students through the steps to create and deliver an oral presentation, and end with playing their golf hole.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

This last lesson helps students reflect upon and show off all the things they've learned. Here, students will create and present their golf-hole designs—either to a select group of people or to the class. Finally, if resources are available, students will set up and play their course for the ultimate satisfaction.

Engaging Students

Get your students interested in the lesson by asking them the following questions:

- What characteristics make for a strong speech? For example, what qualities do you like in teachers or other speakers when they present something to you?
- What have you learned about writing English papers, such as how to create a coherent essay, use transitions, and build unified themes?
- How do you translate a good paper into a good speech?

Project Application: Oral Presentation and Critique

Tell students that they'll be presenting their projects to an audience (for example, to members of the community or to the class, depending on the final outcome of the project). Students will need several class sessions to prepare by getting feedback and practicing their presentations.

Get the ball rolling by asking your students to follow these steps:

1. Have them brainstorm as a group about what they should include in their presentations. Then fill in the gaps. The presentation should include the original presentation board and animation. Talking points might include:
   - Why the student picked his or her theme
   - Challenges and how the student overcame them
   - The math or design techniques the student used
   - The outside research the student did
   - Experiences with partners (classmates or outside mentors)
   - Points of pride in the design
   - The presentation's length–about five to fifteen minutes

LESSON OBJECTIVES AND MATERIALS

OBJECTIVES

- Learn 3-D-modeling software or become more proficient using it

MATERIALS

- 3-D-modeling software or graphics-arts software, such as Autodesk 3-Ds Max, Google SketchUp (free), or Autodesk AutoCAD
- computers to demo and work on

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Project Application: Oral Presentation and Critique (continued)

2. Have students establish, individually or in a group, a logical order of topics (general to specific, first step to last step, etc.).
3. Ask students to draft an outline and to practice delivering the presentation to others. Put students in pairs or in small groups, and have them work on critiquing one another by offering constructive criticism.
4. Determine what information students can put on PowerPoint slides to make the presentation more effective.
5. Have students create a PowerPoint presentation (if the software is available), but urge them to limit the text on any one slide to three lines at the most, with about five words per line. Have students link their presentations to their 3-D computer model.
6. Let students practice delivering the final presentation in small or large groups. Encourage feedback loops.
7. Finally, have students make their final presentations.

Student Assessment

At the end of this lesson, you should have a good idea of each student's skills in creating a cohesive presentation, presenting it, and in the other concepts covered. Here are some guiding points to help assess each student.

The student's mastery of the subject matter is

- **Excellent:** Students present with a strong volume and an enthusiastic tone. They explain their project clearly and persuasively, discussing both the process and product. Students incorporate presentation software such as PowerPoint to highlight main ideas or provide extra visuals, and they've done outside research. Students participate in the critique by covering the strengths and weaknesses of others' projects, and their criticism shows an awareness of the goals of the project and presentation.
- **Good:** Students present using strong volume and a good tone. They explain their project clearly, discussing both the process and product. Students incorporate presentation software such as PowerPoint to highlight main ideas or provide extra visuals, but do so inexpertly. Students participate in the critique, and their criticism shows some awareness of the goals of the project and presentation.
- **Fair:** Students explain their project. They might lack adequate content and resources, such as presentation software. They participate only briefly in the critique, but their criticism is on topic.
- **Poor:** Students are difficult to understand due to one or more of the following issues: poor language or annunciation, a low volume, or incoherence. Students fail to participate in the critique or do so disruptively.

PROJECT WRAP-UP: BUILD OUT AND PLAY

If the resources and time are available, wrap up the project by building the actual course and letting the students play it. In the original program, the school partnered with local architects and contractors to construct the course. However, you can build student holes through different means.

Here are some tips for building out the course:

- Work with the school's art department or woodshop or with parent groups to collect the proper materials.
- Choose which holes to construct based on a class or school vote, or ask participating partners to judge the best holes.
- Build the course off-site, such as at a fundraising event, or on site in the school gym, parking lot, multipurpose room, or classroom.

KEY POINTS

Use the rubrics you've downloaded with this curriculum sample to help assess your students' final presentations.

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Rubric for Assessing Oral Presentation

STUDENT NAME _____ **DATE** _____

CATEGORY	EXCELLENT	GOOD	PROFICIENT	NEEDS IMPROVEMENT
COMPREHENSION 10 points	Student is able to accurately answer almost all questions regarding topic.	Student is able to accurately answer most questions regarding topic.	Student is able to accurately answer a few questions regarding topic.	Student is unable to accurately answer questions regarding topic.
CONTENT 10 points	Student shows a full understanding of the topic.	Student shows a good understanding of the topic.	Student shows a good understanding of parts of the topic.	Student does not seem to understand the topic very well.
PREPAREDNESS 10 points	Student is completely prepared and has obviously rehearsed.	Student seems pretty prepared but might have needed more rehearsal.	Student is somewhat prepared, but it is clear that rehearsal was lacking.	Student does not seem at all prepared to present.
SPEAKS CLEARLY 10 points	Student always speaks clearly, enunciates, and projects voice.	Student mostly speaks clearly, enunciates, and projects voice.	Student rarely speaks clearly, enunciates, and projects voice.	Student does not speak clearly, enunciate, or project voice.

TOTAL POINTS _____

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A Glossary of Common Build SF Terms

Reference this vocabulary list for golf, math, design, and architecture lingo.

Golf Vocabulary

Club: A metal rod about 45-inches long with a thickened end used to hit a golf ball.

Green: The grassy area containing the golf hole.

Handicap: The rating of a golfer's ability, which represents the number of strokes needed to finish a course; the lower the handicap, the better the golfer.

Hazard: An obstacle that makes it harder to get a golf ball into the hole, including a sharp turn, a solid block, or a moving element over the hole.

Miniature golf: A miniature version of a golf course in which players hit a golf ball short distances into a hole. Obstacles or hazards make the game more difficult; the scenery creates a playful atmosphere.

Par: The number of strokes (swings that connect with the ball) it takes an experienced player to get the golf ball into the hole.

Putter: A type of club that players use to hit the ball short distances (usually several feet).

Tee: The small mound or peg from which players begin to play each golf hole; also the act of placing the ball on the tee.

Tee off: To hit the golf ball from a tee.

Math Vocabulary

Angle: Where two lines meet, such as the place where two walls come together to form a corner.

Area: A measurement of two-dimensional space. In a quadrilateral, the area is length times width.

Estimation: An educated guess on an amount or size, often based on comparisons.

Measurement: The act of determining the dimensions or volume of an object.

Perimeter: The border around a two-dimensional shape (or the length of that border).

Polygon: A closed shape with three or more sides; it can be two- or three-dimensional.

Pythagorean theorem: The rule that the square of the length of the hypotenuse (longest side) of a right triangle is the sum of the squares of each of the other sides of the triangle.

Slope: The tangent of the angle of inclination of a line, or the slope of the tangent line for a curve or surface.

Volume: The measurement of three-dimensional space within a three-dimensional shape.

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A Glossary of Common Build SF Terms

Design Vocabulary

2-D (two dimensional): A description of a visual composed of only length and width.

3-D (three dimensional): A description of a visual composed of length, width, and height.

Composition: The visual arrangement of elements in a piece.

Layout: The arrangement of text and images usually within a document or display.

Orthographic drawings: Drawings from multiple views including top, side, and rear.

Perspective: A method of seeing and drawing that allows artists to represent three-dimensional scenes in two dimensions.

Architecture Vocabulary

Arch: A curved opening that allows for more structural stability due to the geometric distribution of stress.

Architect: A person who designs structures with human use, materials, physics, economics, and culture in mind.

Column: A vertical, pole-like support.

Dome: A raised, often half-spherical structure that distributes weight equally (similar to an arch).

Organic: A shape related to a plant or animal form, often referring to any non-linear, non-mechanical shape.

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Troubleshooting Project Implementation Hurdles

Use these tips to overcome potential resource and attitude barriers in implementing the golf-hole project.

by Andrew Brosnan and Jenny Parma; curriculum by Build SF staff

Are you having difficulty setting up the golf-hole project or getting students motivated? Here are some ideas to help overcome these and other issues.

FACING BIAS AGAINST MINIATURE GOLF?

- To counter student biases, make analogies to other small-ball sports such as pool, tennis, and baseball, or reference pro golfer Tiger Woods.
- To counter administrator biases, frame the project as a geometry lesson or reference the many companies that construct courses.

SHORT ON COMPUTERS OR SOFTWARE?

- Expand the drawing exercises to include a greater awareness of color, composition, and typography and headings.
- Increase the expectations for the oral presentation to include a lesson on using note cards, presenting with visual aids, or using research to craft the hole.

LACK OF GEOMETRY BACKGROUND?

- Reframe the project as a creativity project, challenging students to design four distinct holes or to assign different themes to holes.

NEED MORE SPACE FOR SETUP?

- Partner with the physical education department and facilities, especially during winter, to include a leisure-activities week when the miniature-golf course could be set up in the gym.
- Have the class vote on the best three holes and build those in one half of the classroom.
- Have students build scale models only, using marbles as balls and Popsicle sticks as clubs.

INTEGRATE THEMES AND ALTERNATIVES INTO THE PROJECT:

- Themed holes incorporating multiple cultures
- Themed holes incorporating architectural design
- Themed holes incorporating any other lesson (the plot or a character in a book, a genus of animals for a biology lecture, key events in history, different cultures, etc.)
- Holes that highlight a student's experience or expertise (specific music, video games, toys, car knowledge, sports, etc.)
- Holes pushing the boundaries of physics
- Holes that are ADA compliant for wheelchair users

TIPS FOR PITCHING THE PROJECT TO THE ADMINISTRATION:

- Pitch the project on the benefits of project learning.
- Adapt the project to include a current school initiative. For example, if the school is focusing on students' awareness of economics, include a budget lesson that requires students to figure out the cost of building the hole. If the school is focusing on leadership and communication skills, have students build holes in teams of three or four.

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