Cal Teach Student Name(s):	Morgan Rae Reschenberg		
Mentor Teacher Name:	Michael Weitz	**School/Room#:**	Berkeley High, H217
Grade Level and Subject:	High School IB Math Analysis (11th grade)		
Date & Time to Be Taught:	10 April 2017; 5th Period (1:58 - 2:41)		

Lesson Source(s):	Education 130
Focus/Essential Question:	How does the orientation of a 3D shape affect the 2D shape of its cross section?
Student Learning Objectives:	Students will understand that different 2D shapes can be generated by slicing or bisecting the same 3D shape at different points.
Content Standards:	MA.5.0 Students are familiar with conic sections, both analytically and geometrically MR.2.5 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
Student Prior Knowledge:	Students have taken either Geometry or an Integrated Math equivalent course. Students have worked with conic sections and are familiar with how to generate different 2D shapes from a 3D shape.
Lesson Agenda for Your Students:	- Warm Up: What are conic sections? What are cubic sections? - Cube Problem 1: Edgewise - Cube Problem 2: Corner-wise - Debrief: Solutions and Approaches
Lesson Rationale:	Visualisation and manipulation of 3D objects is essential to student success in mathematics and other technical subjects. Using models and visual aids to assist in breaking down a problem also gives students the opportunity to make mathematics more concrete.

Materials and Technology List:	Student Materials: Pipe-cleaners, playdough, plastic knives, cube models, tape, pencils, pens, paper Teacher Materials: Camera, camera batteries, tripod, volunteers to film, printed lesson plan copy
Preparation Tasks:	Collect supplies, arrange cameras, instruct students on how to arrange desks
Safety Concerns:	Students should exercise caution with plastic knives

Lesson Title: Cubic Sections	**Evaluate:** *Observe and adjust your lesson as you teach.*
Engage: *Activities that engage students' interest and build connections to their lives and prior knowledge.*	*Previous Experience and Baseline Learning*
First, students should be arranged into groups. Desks are normally in rows, and students should turn their desks to form groups of five or six students depending on attendance (NOTE: in 4th period there are 28 students, in 5th period there are 32). After students have arranged their desks, they will be given the following prompt and instructed to discuss with their group members: **In the past few weeks, you've done a lot of work with conic sections (parabolas, hyperbolas, circles, ellipses, etc.). Today, we're going to be doing some work with cubic sections. Remember that with conic sections, we obtained those shapes I just mentioned by looking at the cross sections, or faces, of the sections we cut away from the cone. With cubic sections, we'll be doing the same thing.** Here, students may find a visual reminder helpful. My mentor teacher has a model of a cone cut away at various angles to produce conic sections. If students seem unsure, I may hold up the model to jog their memory as we go through the shapes together. **I want you to imagine the following: You have a cube in front of you lying flat on the table--that is, one of the six faces of the cube is flat against the surface of the table. The cube is half-filled with water (water takes up half the volume of the cube). You tilt the cube left or right such that now only one of the edges is in contact with the table. After the water has settled, what is the shape of the surface of the water? The cube is a unit cube--each of the sides is of length 1.** **With your group, come to a consensus about the shape you believe the surface of the water creates. In a few minutes, I'll walk around and ask each group for their shape. We'll compose a list on the board.** By asking each group individually about the shape they believe the cross section to be, there is more likely to be a variety of responses than there is if students were asked to call out their shape in front of the entire class. After collecting student answers, ask a few groups to volunteer how they solved this problem--if "drawing", show their drawings on the projector or invite them up to the board. If students claim they "just knew" the answer, draw the problem on the board anyway to help students who may be lost and afraid to vocalise. Because these students have been working with conceptual geometry for the past few weeks, I imagine this problem will go smoothly and	- Students may need clarification of the problem; if the water example doesn't work well, change language to emphasise that what we're looking for is the shape of the face when the cube is cut in half. Using hand motions may also help students understand - Though they may start with no supplies or nothing on their desks, if students seem frustrated or lost, encourage them to get out paper and pencil to draw out their thought process. - Again, encourage communication within the groups. Students are sitting together because the problems are supposed to be social - If discussion gets out of hand or students seem to be addressing each other inappropriately, redirect to whole-group discussion and draft some discussion norms. Follow school disciplinary procedures if necessary. - Students should draw on their knowledge of special triangles and geometric shapes for this section.

quickly. **Time**: <u>About 15 minutes</u>	
Explore: *Hands-on tasks designed to explore ideas and to develop skills together.*	*Focus, Involvement, Collaboration, Results, and Recording*

After collecting student approaches for the first problem and walking through how students reasoned the cross section to be a rectangle, give students the following problem:
 	
Go back to the cube we had before. It's still a unit cube and it is still half filled with water. Instead of tilting it onto one edge, I want you to imagine tilting it onto one corner. First, we had the cube resting on the table--the entire face was in contact with the table. Then, in our last problem we tilted it so only the edge--a line--was in contact. Now, I want you to tilt it forward or backward from the edgewise position such that the entire cube is balanced on one corner--only one point is in contact with the table.
In this orientation, I want you to do the same thing we did before--find the shape of the cross section. Talk about this with your groups as I come around again to get a list of possible shapes.
 	
As students discuss with their groups, I will gather the wooden cube models and distribute them as each group tells me what they think the shape of the cross section will be. I will compile a list on the board in the same fashion as before.
 	
Time: <u>About 10 minutes</u>
	- Be prepared for student questions on the problem; like before, the water example may cause confusion for students. Revert to "cutting" or "bisecting" the cube if this is easier for students to understand
	- If there is a large amount of confusion about orientation from the previous problem, pass out cube models before explaining and show students the orientation with a model at the front of the room
	- It may be helpful to write certain conditions on the board:
	  - The cube is a unit cube (dimension model)
	  - ½ water volume
	  - Only 1 point in contact with table surface
	- Student drawings from the last problem may help students think about how to build off of what they already know; leave these on the board

Explain: *Students explain the phenomena they explored and discuss their different ideas and perspectives.*	*Participation, Reporting, Debating, and Evidence-Based Reasoning*
After giving students five minutes to discuss, I'll inform them of the materials available to use for modeling and encourage them to think of ways to either help them understand the problem better or, if they already have an answer, think of ways to best demonstrate/substantiate their answer for the class. Some students may be reluctant to try modeling without having a	- Remind students materials should be shared among groups and only taken back to their desks when needed - Students should also be encouraged to consider the limitations of the models

concrete idea of the shape of the cross section; they should be encouraged to play around with the materials to see if anything sparks their interest. **Time:** <u>About 20 minutes</u>	they're using: is the playdough too squishy and distorting your shape? Is your model more rectangular than cubic?
Elaborate: *Teacher-stimulated application and clarification of concepts, skills, attitudes, processes or terminology.*	*Demonstrated Understanding, Use of Skills, and Other Applications*
As students work in their groups, I'll walk around and try to direct them or help clarify the problem if necessary. I expect the students to be engaged with the problem, but I anticipate that students may have a hard time moving away from only drawing or only visualising the problem. If students have finished the problem early, I'll encourage them to find the area of the cross section they discovered. I will also ask them about the other shapes it is possible to generate from the cube: What is the equivalent "circle" for a cube? (in relation to conic sections). What about the parabola, hyperbola, etc.? **Time:** <u>About 10 minutes (partially overlapping with previous time of discussion)</u>	Guiding questions: - If students are using the corners as the "halfway" points: how can we find the halfway points? how long is the path up the cube? where would the halfway points be? - If students are using models that may be inaccurate or poorly constructed/misshapen: use whole pipe cleaners for even sides, use less pressure when cutting the playdough
Evaluate:	
At the end of the class, students will elect a representative from each group and give a short 1-2 minute overview of what they tried and how they reasoned through the problem. They will also share their conclusions and how their models helped confirm or deny what they initially suspected the cross section to be. If they attempted the additional problems, they will have a chance to present their findings as well. Students will be evaluated largely on participation and effort. Because this is a topic students have dealt with before, they should have no trouble applying their previous knowledge of conic sections in this new context.	Guiding questions: - What did you think initially? - How did you go about trying to prove your intuition? - When did your thought process start to change? - What conclusion did you reach?