In this lesson, students will experience the engineering process when creating modifications to a familiar game.

### Materials:
- Copies of Ultimate Tic Tac Toe game boards, or blank white paper
- Pens/Pencils
- Computer w/ Internet connection & projector
- Rubik’s Cubes (original 3x3)

### Texas Essential Knowledge & Skills

#### Engineering Design & Problem Solving (CTE) - 130.412.8 A-I
*The student creates justifiable solutions to open-ended real-world problems using engineering design practices and processes. The student is expected to:*

- (A) identify and define an engineering problem;
- (B) formulate goals, objectives, and requirements to solve an engineering problem;
- (C) determine the design parameters associated with an engineering problem such as materials, personnel, resources, funding, manufacturability, feasibility, and time;
- (D) establish and evaluate constraints pertaining to a problem, including health, safety, social, environmental, ethical, political, regulatory, and legal;
- (E) identify or create alternative solutions to a problem using a variety of techniques such as brainstorming, reverse engineering, and researching engineered and natural solutions;
- (F) test and evaluate proposed solutions using methods such as models, prototypes, mock-ups, simulations, critical design review, statistical analysis, or experiments;
- (G) apply structured techniques to select and justify a preferred solution to a problem such as a decision tree, design matrix, or cost-benefit analysis;
- (H) predict performance, failure modes, and reliability of a design solution; and
- (I) prepare a project report that clearly documents the designs, decisions, and activities during each phase of the engineering design process.
**Background Knowledge:**
Students should know how to play the traditional tic tac toe. If not, they can certainly be taught very quickly.

**Procedure:**

**Before class:**
- Learn how to play Ultimate Tic Tac Toe.
- Make copies of Ultimate Tic Tac Toe game board, or have blank paper ready for students.

**Part 1- Learn a New Game**
1. Teach Ultimate Tic Tac Toe to students.
   a. Project game board for Ultimate Tic Tac Toe from website onto white board (ultimatetictactoe.creativitygames.net) - or draw a few tic tac toe grids on chart paper
   b. Challenge a few students (one at a time) to traditional tic tac toe.
   c. Explain that if both players are paying attention- and reasonably intelligent- most games will end in a draw/ tie.
   d. Challenge the computer player to Ultimate Tic Tac Toe and have students observe. Talk through some of your moves, discussing the strategy of why you would or would not choose certain squares.
2. Pair students up and have them challenge each other. If you have an odd number of students, the teacher can play against them, or let them play against the computer. They can draw the grids on blank paper or you can make copies of the supplied game board.

**Part 2- Analyze Traditional / New Game**
1. Discuss:
   a. How does the new version “ultimate tic tac toe” change the difficulty of the game?
   b. Which version do you prefer?
   c. How else could tic tac toe be modified?
Part 3- Modify a Game Further, Analyze Again

1. Discuss:
   a. How could you use Rubik’s Cubes to play tic tac toe?
   b. What rules need to be created?

2. Have students write up their game modifications and teach their new versions to another student / small group.

3. Discuss as a class some of the problems encountered when using Rubik’s Cubes to play tic tac toe. (Example: How to make a move without “undoing” your opponent’s move, or maybe this is a strategy and part of the game.)

4. Discuss how could these problems could be solved, and how some students may have taken these issues into account in their own game versions.

5. Allow students to share their various modifications for the game.

6. Send students ‘back to the drawing board’ to make adjustments to their game and try out their revised versions with a partner or small group.

Technology Connection:
Ultimate Tic Tac Toe can be played online here: http://ultimatetictactoe.creativitygames.net/ This site could be used when demonstrating how to play the game, or the students can challenge the computer or play 2 players online.

Notes to Teacher:
3x3 Rubik’s Cubes are available to borrow from the You CAN Do the Rubik’s Cube Lending Program at no cost other than return shipping. www.youcandothecube.com/lending-library

Ultimate Tic Tac Toe rules/ description can be found online here:
https://mathwithbaddrawings.com/2013/06/16/ultimate-tic-tac-toe/ or search “ultimate tic tac toe” online for many variations.
Ultimate Tic Tac Toe

Image is screenshot from http://ultimatetictactoe.creativitygames.net/
Engineering Design Process

When working on a problem that involves designing, building, and testing something, engineers often use the Engineering Design Process. The steps are listed in the graphic below. Describe how you used the Engineering Design Process while creating your version of tic tac toe using Rubik’s Cubes.