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TANIYA MISHRA

Designing an Artificial Intelligence to Become a Great Engineer

STEM Lesson Plan for Grades 6-8

Helping all students, especially girls, to be interested in engineering as a possible future can be challenging. Research suggests that role models are important for helping students to see themselves in a jobs where they have been underrepresented. In addition, having challenging and fun engineering experiences help students to want to become engineers.

Many engineering projects though are focused on competitions, but that isn't the essence of engineering. The cycle of determining a problem, identifying what's needed to solve the problem, trying and testing possible solutions, and optimizing and iterating to find an adequate solution is what makes an engineering project.

NGSS Standards
CCC: Structure and Function
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

In this lesson plan, students will watch a video where Taniya Mishra explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer, they will investigate how to develop a simple artificial intelligence project. Finally, they will look back at their work habits to determine how closely they matched skills that the engineer suggested were important.

Part I: Watching the Taniya Mishra Video

Before the students watch the video, the teacher should explain that in this video an engineer will explain what makes her a successful engineer. The teacher should ask students to record what personality traits, desires, and behaviors are important to becoming an engineer.

For younger students, you may need to use sentence starters like

Taniya Mishra said that she had to overcome the obstacles of _________

Taniya Mishra said that she wants to _______

The video has on-screen icons that will help students when she is saying key components of her success. For some students, pausing the video at those moments will help them better record what is going on.

In small groups have the students summarize what they saw and then make sure that the entire class has all of the points. While they may have more than these, they should at least note:

- Taniya Mishra succeeded as an engineer because she was put on the right career track.
- Taniya Mishra loves engineering because she gets to be creative.
- Taniya Mishra succeeded as an engineer because of teamwork.

Making a Great Engineer Checklist

Students now should now make a checklist of things for themselves to do if they want to be a good engineer. Then when they do something on the checklist, they should mark it off. For example

Activity	
I helped someone	卌 I
I didn’t give up when something didn’t go the way I planned	卌 III

Students will use this checklist several times in the following projects. Don’t assign points or give too much praise, otherwise students will just game the system. We just want them noting when they are doing something a good engineer does, helping them to internalize that they can be an engineer. Alternatively, you can make it the task of one of the members of the group to note when their groupmates are being good engineers.

Part II: Engineering Cycle

Artificial intelligence is usually associated with computers, but AI existed before them as any system that mimics human intelligence or reasoning can be considered AI. Early incarnations included strategies for games, especially ones that were complete enough that players could win by following instructions without having to make any decisions on their own.

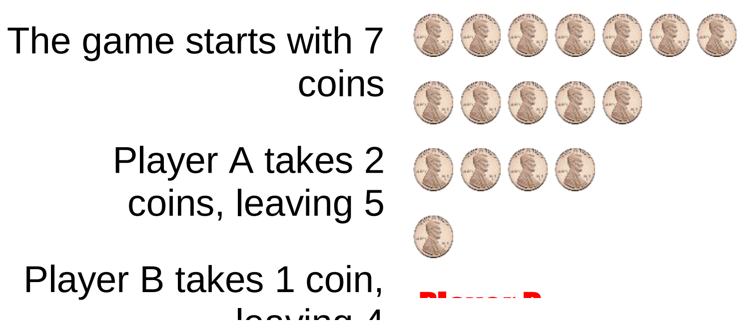
Students will start with a fairly basic game and develop a system that can always win. They will be introduced to decision trees, and then they will expand their system to more complicated games. They will conclude with developing a scheme for tic-tac-toe.

Materials

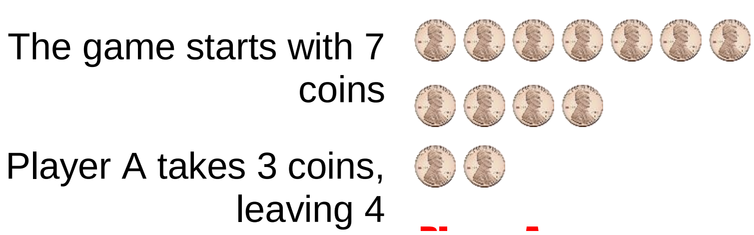
- 14 coins
- Large paper
- Small slips of paper, Post-It Notes, or index cards

A First Attempt: 7-Coin Subtraction Game

Seven coins are laid out between two players. In alternating turns, each player must take one, two, or three coins. Neither player can pass, choose to take zero coins, or try to take more than three coins. The player to take the last coin is the winner. A couple of examples follow.



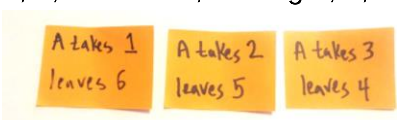
Or



Have students play the game many times. Tell the students that a strategy is known to exist that guarantees a win for the player that goes first no matter what the other play does. Ask them to look for this strategy. You may wish to scaffold this search by introducing decision trees which are graphical devices that show all the possible outcomes of a set decisions that follows through to the end of the game.

Making a decision tree is relatively straightforward but sometimes tedious project. Typically, one starts by noting all the possible choices for the first move. It can be convenient to write them on Post It notes or index cards so that they can be rearranged easily.

For example, in the 7-Coin Subtraction game, there are three initial options for Player A. A takes 1, 2, or 3 coins, leaving 6, 5, or 4 coins respectively.



Looking at the first option, Player A taking 1 coin, Player B has three options, taking 1, 2, or 3 coins.

If B takes one or two coins, then A has the usual three choices. However, if B takes three coins, that leaves only three coins, and Player A can take all of them and win.

Each one of those scenarios can still be filled out some more.

Now, every possible winning situation from Player A taking one coin in the first round has been sorted, excluding some situations where players don't make winning moves when they can. From the decision tree, we can see that if B takes one or three coins after A's initial move taking one, there is a path for A to win. On the other hand, B will always win no matter what A does if B takes two coins.

The decision tree isn't complete though. The situations where A starts the game by selecting two or three coins hasn't been sorted. They are displayed below.

Taking two coins, doesn't guarantee a win. If A takes 2 coins and then B takes 1 coin, no matter what A does next, B will win. If A takes three coins on the first move, however, no matter what B does, A will win.

Using this information, students can write a set of instructions that a person or machine could follow mechanically and always win. For example, they might say:

Winning Strategy for the Player Who Goes First

1. Take thee coins on the first move.
2. Second player takes some number of coins.
3. Take the remaining coins (which will always be three or fewer) to win.

Changing the Game: 8-Coin Subtraction Game

To test their strategy making skills, change the game. Ask the students how would the strategy change if the game used eight coins instead of seven. After playing for a while, most of the students will figure out that Player A no longer has a guaranteed winning strategy. In fact, Player B can always win. It will probably be good for the students to make a decision tree for the 8-Coin game as well (appended at end). A possible strategy follows.

Winning Strategy for the Player Who Goes Second in 8-Coin Subtraction Game

1. If Player A takes 1 coin, Player B should take 3 coins.
   If Player A takes 2 coins, Player B should take 2 coins.
   If Player A takes 3 coins, Player B should take 1 coin.
2. Player A takes some number of coins.
3. Take the remaining coins (which will always be three or fewer) to win.

Have students try out their strategies by giving them to another student and have that student follow them. Explain that their strategies have to be clear enough so that the other person can use it without having to think. The strategies are going to do the thinking for them. Remind students that when trying out their partner's strategy, they should be following the instructions exactly. Students may need help understanding how specific the instructions need to be. You may find it helpful to try one or two with the whole class.

N-Coin Subtraction Game

Assign students (or small groups) the task of examining a Subtraction Game of 9, 10, 11, 12, 13, 14, or 15 coins. First, have them try to determine whether Player A or Player B can have a guaranteed win. Second, have them develop a strategy so that Player always wins. Again students should test their strategies by using them against another student.

For students that are struggling help, them by having them compare a seven coin game to an eight coin game. Ask them to look for a point in both games where a guaranteed win will occur. You may need to mention to younger students that a guaranteed win occurs when no choice made by the other player can affect the outcome. Many students will notice that when players cause only four coins to remain, they are will always win. With seven coins, Player A can cause that to occur on the first turn. With eight coins, Player A can't remove enough coins to cause only four to remain. After Player A removes one, two, or three coins, Player B can remove three, two, or one coin, respectively, to leave only four.

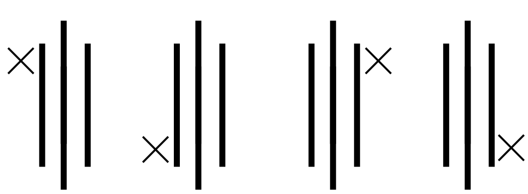
Another way of looking at the game is to have players look at a 9-Coin game can be turned into a 7- or 8-Coin game by removing either one or two coins on the first move. Since the students know what will happen in an 7- or 8-coin game, they should know what they want to do in the first move.

After students present their strategies, see if they can make a single strategy that will work for any number of coins.

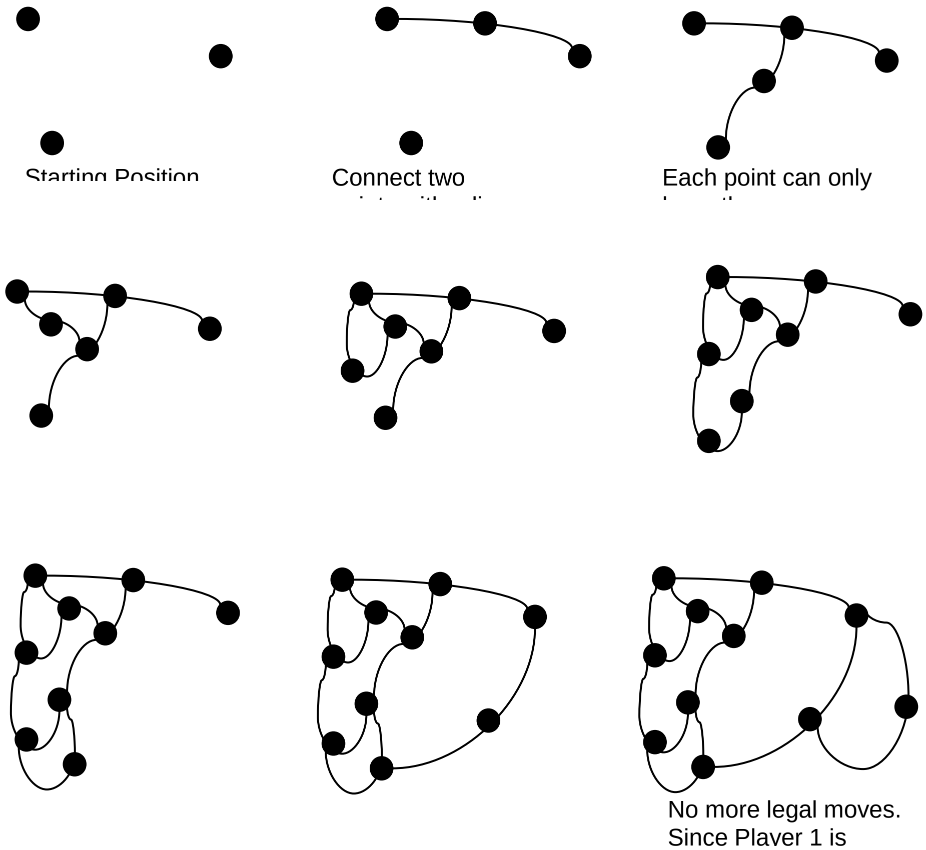
Different Games

Finally, you might have groups try to create strategies for modifications of the Subtraction Game. Options include having three players, being able to remove 2, 3, or 4 coins, or adding coins. More advanced students, you might give the option to make a strategy for a different children's game.

For example, most students over the age of 10 will know that ***tic-tac-toe*** (sometimes called naughts and crosses) will always lead to a draw if everyone plays their best game, but they might not have actually considered what they are actually doing. Have students write up a strategy for winning or at least tying at tic-tac-toe. There are a lot more choices in tic-tac-toe than in coin subtraction games, but you might help students realize that there are really only three openings: corner, center, or edge. For example, all four corner moves are the same but different rotations or reflections.



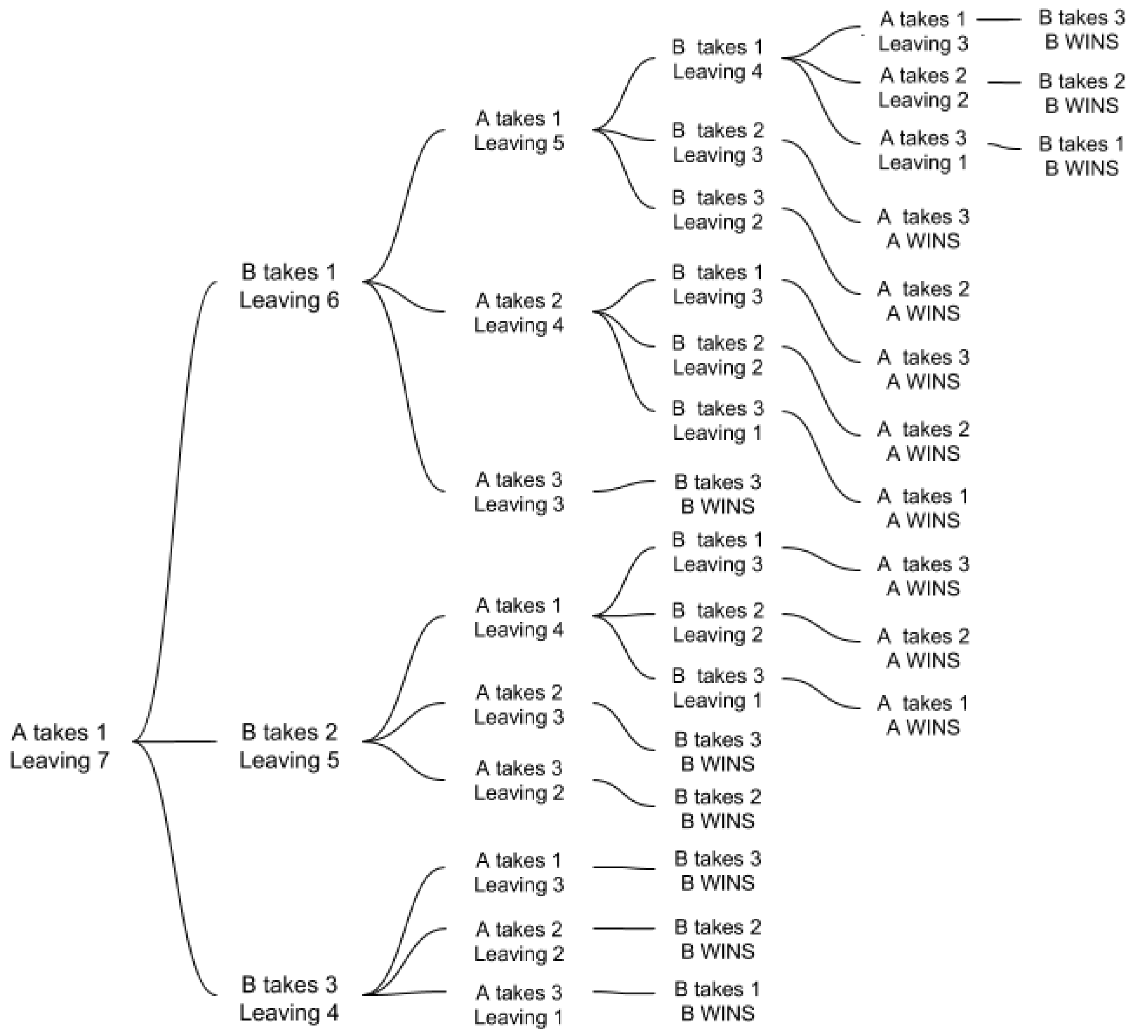
Another game that might interest students is ***Sprouts***. Sprouts starts with laying down some number of dots. A player then connects two dots together with a line. Somewhere along that line, students will add another dot. Every dot can only have three lines touching it. The player that can't make a move loses.

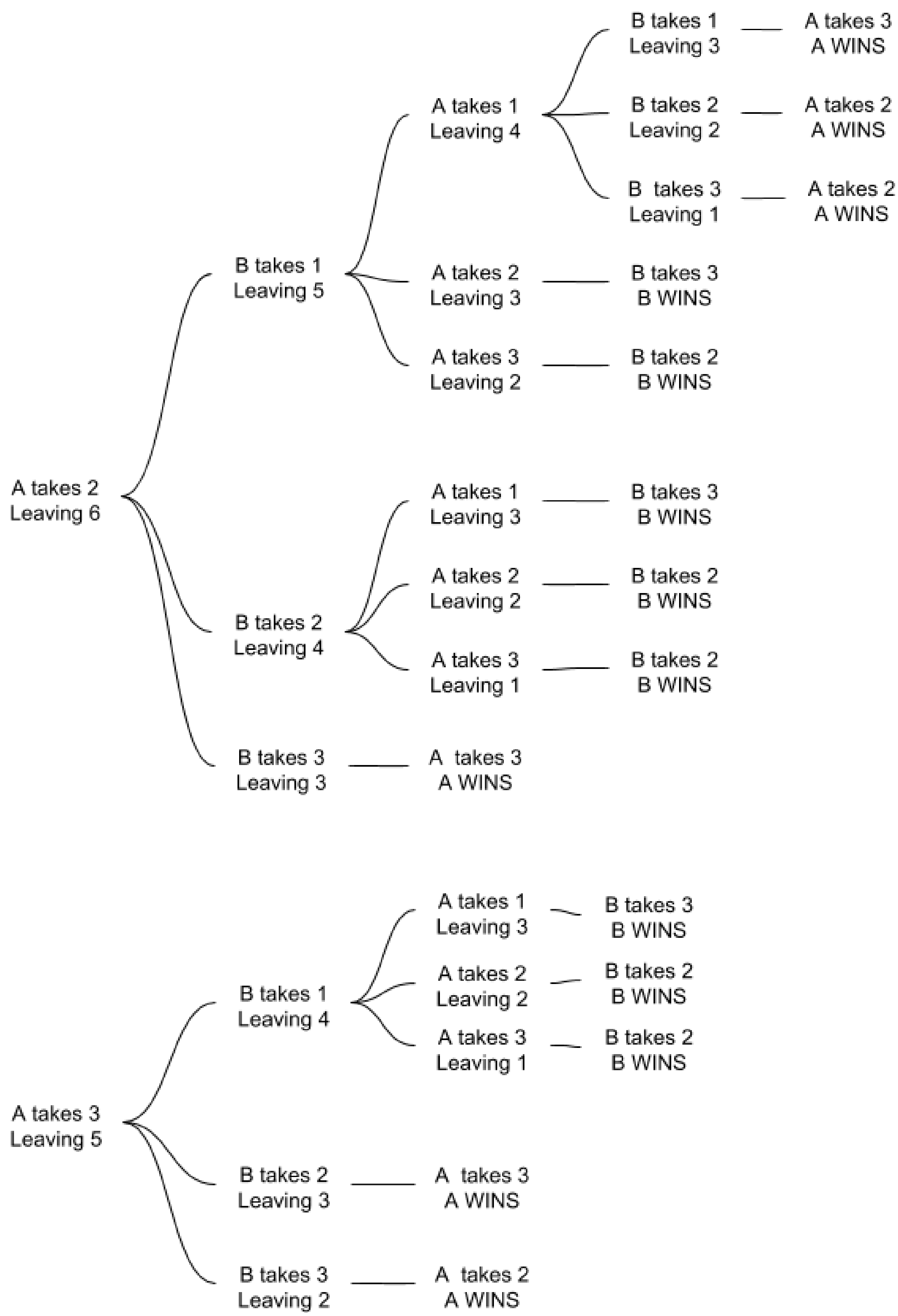


Part III: Evaluation

These kinds of assignments can be tricky to assess as they are mostly pass-fail in that either the strategy works or it doesn't. Probably the best plan is to have students examine how well the responded to set backs and have the reflect on what strategies they developed for making strategies.

8-Coin Decision Tree




A takes 2
Leaving 6
B takes 1
Leaving 5
A takes 1
Leaving 4
B takes 1
Leaving 3
A takes 3
A WINS
B takes 2
Leaving 2
A takes 2
A WINS
B takes 3
Leaving 1
A takes 2
A WINS
A takes 2
Leaving 3
B takes 3
B WINS
A takes 3
Leaving 2
B takes 2
B WINS
B takes 2
Leaving 4
A takes 1
Leaving 3
B takes 3
B WINS
A takes 2
Leaving 2
B takes 2
B WINS
A takes 3
Leaving 1
B takes 2
B WINS
B takes 3
Leaving 3
A takes 3
A WINS
A takes 3
Leaving 5
B takes 1
Leaving 4
A takes 1
Leaving 3
B takes 3
B WINS
A takes 2
Leaving 2
B takes 2
B WINS
A takes 3
Leaving 1
B takes 2
B WINS
B takes 2
Leaving 3
A takes 3
A WINS
B takes 3
Leaving 2
A takes 2
A WINS