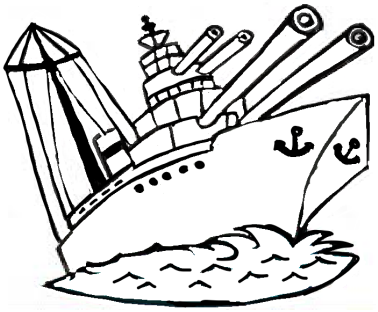
Battleships Lesson Plan

5th Class Maths

Kerry Brooks and Eoin Delaney



Abstract

We introduce the game of Battleships through the lens of probability. This lesson should be really enjoyable for students as they are learning whilst playing a game. We begin by introducing the rules and providing the students with a 3 x 3 battleships grid. Students will play the game and record how many guesses it took to sink a ship. A frequency table will be completed. Students will record their results and display them graphically using bar charts. We will analyze the number of possible arrangements for a boat to be placed in the grid. We will consider which boxes are most likely to have a battleship in them and why this is the case. Students will then be encouraged to work out a mathematical strategy to play the game. A larger grid will then introduced and we can vary the boat size. Students will be encouraged to find the best places to place their battleships in these grids.

1 Learning Outcomes

According to the Curriculum documents (NCCA, 1999), students should be able to;

- Identify and list all possible outcomes of simple random processes
- Estimate the likelihood of occurrence of events
- Construct and use frequency charts and tables
- Collect, organise and represent data using single and multiple bar charts
- Read and interpret single and multiple bar charts

2 Learning Intentions

Upon successful completion of this lesson, students will be able to;

- Count the number of possible arrangements when placing a battleship into a 3 x 3 grid.
- Determine which squares in this grid contain the largest number of possible outcomes.
- Collect experimental data for different games. (How many guesses it took to sink a ship)
- Fill experimental data into to a tally chart.
- Analyze the bar chart.
- Recognize that certain squares are more likely to contain a ship based off probability.
- Apply this knowledge to a 4x4 grid and a game with a larger ship. Design an optimal strategy for these games based off probability.

3 Lesson Rationale

3.1 Prior Knowledge

In previous years students should have encountered the strands chance and representing and interpreting data. According to the curriculum documents (NCCA, 1999) students should already be able to;

- Use the vocabulary of impossible, unlikely, likely and certain
- Order events in terms of likelihood of occurrence
- Identify and record outcomes of simple random processes such as tossing a coin ten times.
- Collect and organize data (From Nature walks etc)
- Represent data in a frequency table and tally chart

3.2 Resources Required

- Battleships Workbook (See our attached workbook!)

3.3 Common Student Misconceptions

- The rules of the game may be a grey area for some students. Some students may try to put their ship diagonally across the grid.
- It is important to emphasize that winning the game isn't the ultimate objective and our results will only work if the children are honest and don't cheat.
- Playing the game without counting how many turns it took to win.
- Errors in reading data from a bar chart.

3.4 How will learning be assessed?

- Asking students to make some statements about the results. "What does this mean?" ... "Is there a best square to place the ship?"... "Are there regions I should avoid placing this ship?"...
- Watching and listening to students as they play the game

4 Lesson Flow

Timing	*Learning Activity*	*Notes for Teacher & Scripted Questions*
5 mins	Introduce Battleships The Rules	Can not place ships diagonally Emphasize that children need to be truthful in playing the game for the lesson to work
10 mins	Playing a game in pairs Gathering data on how many turns in took to sink the ship	Go through an example of what a turn is
15 mins	Filling in the frequency table Making a bar chart	Gathering data off children How many people sunk the ship in six turns?
10 mins	Going through number of possible combinations of ship placement Examining which squares are most likely to contain a ship	Whats the total number of squares in the grid? Is there a best place to put the ship?
10 mins	More complex grids Exercises Scratch quiz	Review and reflect

5 The Mathematics Behind Battleships

5.1 Probability and Squares

Guessing the position of a battleship should be guided by probability. In order to develop a strategy we must consider the grid.

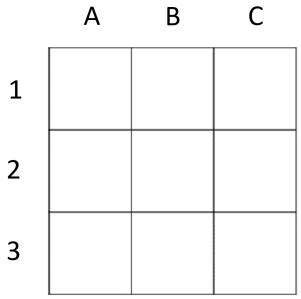
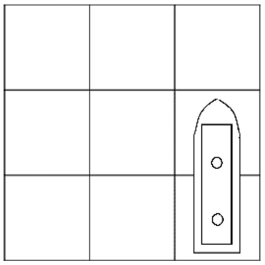
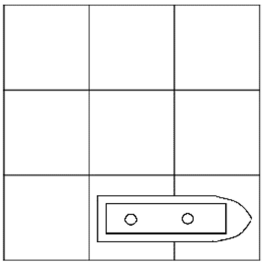


Figure 1: Playing Grid

As you can see in fig.1, there are nine squares in total for the 3 x 3 grid. Each battleship takes up two adjacent spaces on the grid. It is important to note that the orientation of the battleship is irrelevant. Figure 2 shows two possible combinations of arranging the battleship on the grid. In total there are twelve unique ways of arranging a ship in this grid. Note that the ships cannot be arranged in a diagonal manor.



(a) Possible Combination



(b) Possible Combination

Figure 2: Two possible ways of arranging the battleship

We should also note which squares are occupied by a battleship. Figure 2 demonstrates that there are only two possible arrangements where the battleship lies in the C3 square. However, the middle B2 square can be occupied in four possible unique arrangements. This means that if a battleship was randomly placed on the grid there would be a 2/12 chance that a portion of it was in the C3 square and a 4/12 chance that a portion of it would be in the B2 square. This highlights how our guess should be guided by probability as some squares are more likely to be occupied by a battleship!

5.2 The Best Squares to Guess

As discussed in the previous section a randomly placed ship is more likely to occupy some squares. The diagram below highlights how many times each square is occupied for the twelve unique combinations of set-ups.

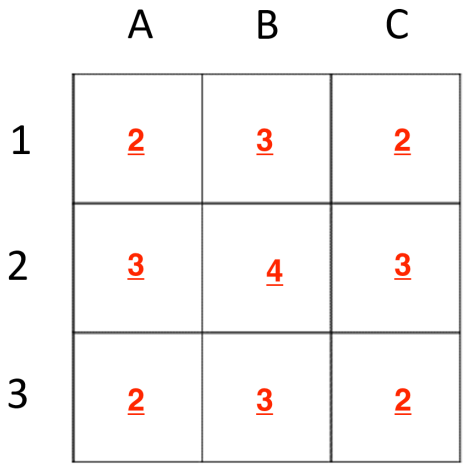


Figure 3: Square Occupation

Of course when you hit the ship for the first time your guesses should build on the information you have gained. For example, if on my first guess I choose to fire a missile at the A1 square and this missile hits a target, I know that I have at least a 50% chance of sinking the battleship in my next turn because it must be on A2 or B1.

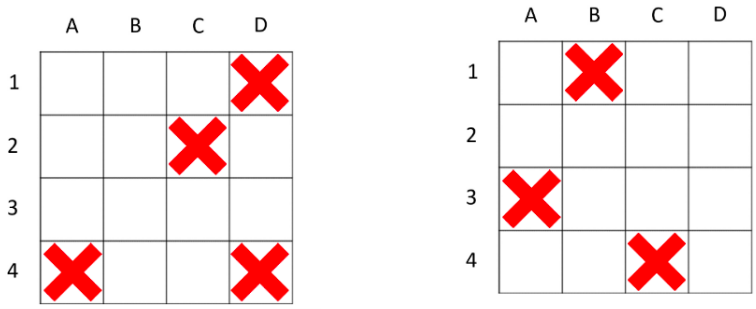
5.3 Gathering and Analyzing the Childrens data

It is important to ask children to remember to count how many turns it takes them to sink the opponents battleship. We expect this to be roughly normally distributed with most games being completed after five or six guesses. Of course some games will take only two turns whilst some might last the full nine turns. The teacher should make sure the frequency table in the workbook is correctly filled in and work with the students in designing the bar chart.

5.4 More Complex Games

It is also possible to introduce a 4 x 4 grid and keep the size of the battleship the same. However, we believe working out the associated probabilities with this larger grid is beyond the scope of the curriculum. Of course this is entirely up to the teacher and if one wishes to challenge their students or use this concept for an older class group we strongly encourage the design of more complex exercises.

We have devised some exercises suitable for 5th class children where a number of turns have already be completed, thus simplifying the game. In the following exercises the children are provided with a grid as shown below. The children are instructed to colour in the square that is now most likely to be occupied by a battleship. They must again list the number of possible times a square can be occupied by a battleship.



(a) Possible Game 1

(b) Possible Game 2

Figure 4: Two possible games

The exercise for the first figure has been completed below.

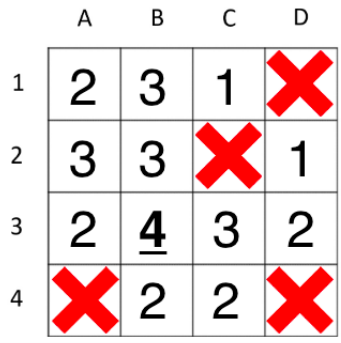


Figure 5: Solution to the exercise