Desmos Battleship

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Introduction

Battleship is a game of guessing, strategy, and logical thought that has been around since the 1930s. In the game, players position ships of various sizes on a grid that their opponent cannot see. Players take turns guessing the location of the ships and the game continues until all of one player's ships are sunk. This game can be adapted to incorporate mathematics by using Desmos, a free online graphing calculator that runs in the window of any modern web browser.

The U.S. Common Core State Standards (CCSSI, 2010) state that mathematically proficient students "are able to use technological tools to explore and deepen their understanding of concepts" (p.7). NCTM's (2014) *Principles to Actions* reinforces this in that "an excellent mathematics program integrates the use of mathematical tools and technology as essential resources to help students learn and make sense of mathematical ideas, reason mathematically, and communicate their mathematical thinking" (p.78).

The Australian Curriculum: Mathematics (ACARA, 2014) echoes these ideas in its emphasis on the integration of technology to deepen students' learning. *The Australian Curriculum: Mathematics* (ACARA, 2014) includes a Year 10 Content Description that emphasises the importance of exploring the connection between algebraic and graphical representations of circles using digital technology as appropriate; as well as to graph linear relationships with the use of digital technologies in Year 8.

Desmos Battleship

Desmos Battleship is an engaging activity in which students can improve their visualisation skills, and deepen their understanding of linear functions and circles by making connections between algebraic and graphical representations. The Desmos Battleship activity was used in a Saturday STEM (Science, Technology, Engineering, and Mathematics) program, conducted with students in Years 7 and 8. Prior to conducting this activity with the school-aged students, it was trialed with pre-service teachers to test the instructions for clarity and also to obtain feedback that might be useful in modifying aspects of the activity that they would complete.

Setting up the game

Students open Desmos [https://www.desmos.com/] in a new web browser, and click on the "start graphing" box. In order to ensure that all players are working from the same coordinate grid, the x-axis and y-axis should be set to go from –15 to 15. This can be done by clicking on the wrench icon (circled on Figure 1) located on the top right of the sample screen.

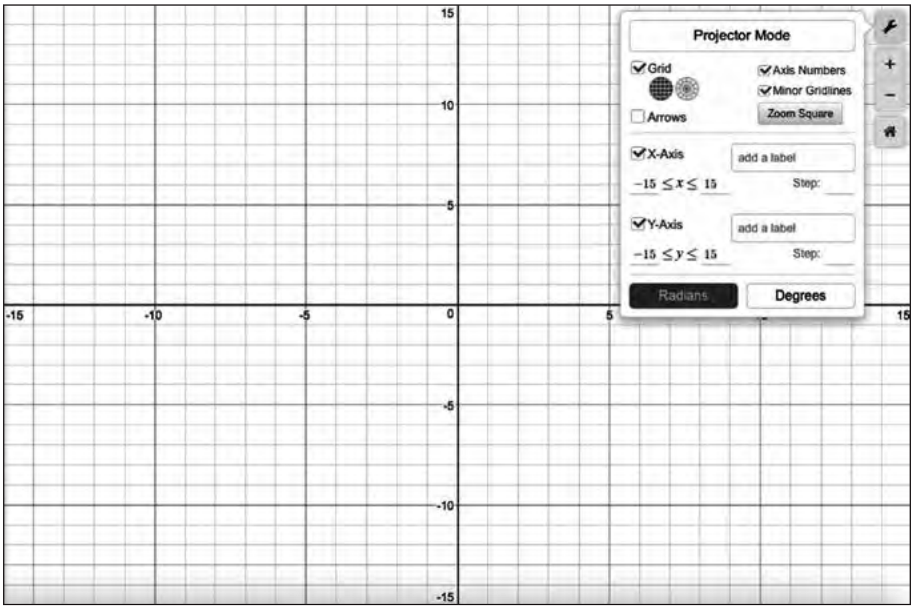

Figure 1. Setting up the game.

For this game two students on a team play against two students on another team. Each team gets three ships. The ships are inputted as linear equations into Desmos. The domain or range of the linear equation is restricted so that the domain or range interval is 2 units, 3 units, and 4 units. Figure 2 shows three possible ships. Restricting the domain or range is completed in Desmos by using curly { } brackets. It is important to emphasise to students that when they restrict the domain or range, they need to ensure that their ships can still be seen on the coordinate plane set up for the game and that their whole ship can be seen. For example, if the third equation was $y = -x + 18$ $\{2 \le y \le 6\}$, then the part of the ship from $2 \le y \le 3$ is not visible on the screen. [Note: stop at this point before explaining how to play the game to ensure that all teams have their ships properly setup].

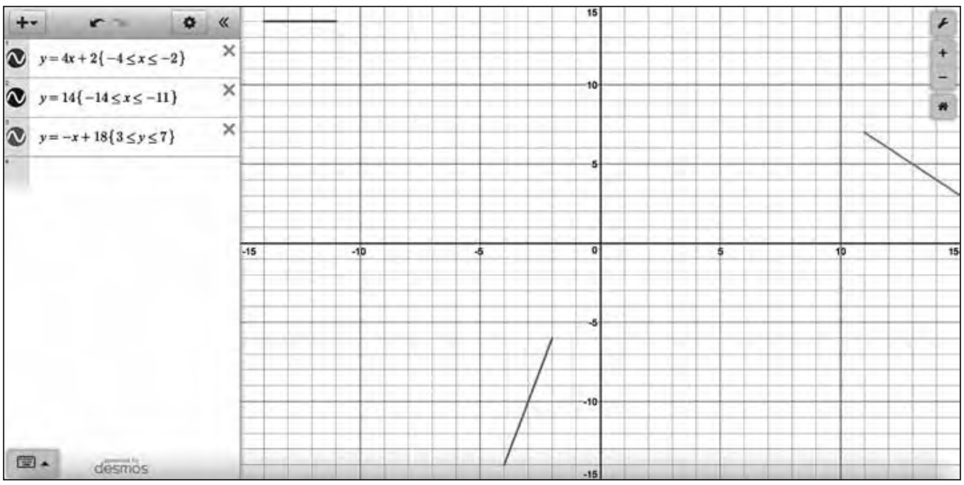

Figure 2. Three possible ships.

Playing the game

Teams alternate turns until all three of one teams ships are sunk. Ships are sunk through the use of circles. If any part of a circle or the inside of a circle touches a ship, that ship is sunk. The circles have different radiuses based on a roll of a die. The die is rolled before every turn. Initially, when establishing the game setup the largest possible radius of 3 associated with the numbers on the die was fixed. However, after trialing the activity with pre-service teachers, feedback that they provided suggested the following modification in order for the game to go faster, and also because it worked better with the roll of the die. Suggested game modification: if a die roll is: 1-set a radius of 1; 2-set a radius of 2; 3-set a radius of 3; 4-set a radius of 4; 5-set a radius of 5; 6-set a radius of 6.

Teams get to pick the centre of their circles, which can be any point in the co-ordinate plane. The equation of a circle was shared with students:

$$(x - h)^2 + 2 + (y - k)^2 = r^2$$

with the centre of the circle being (h, k), and the radius being r. The example in Figure 3 was used to show students how a ship could be sunk, and also to explain how the circles centre relates to the equation of the circle.

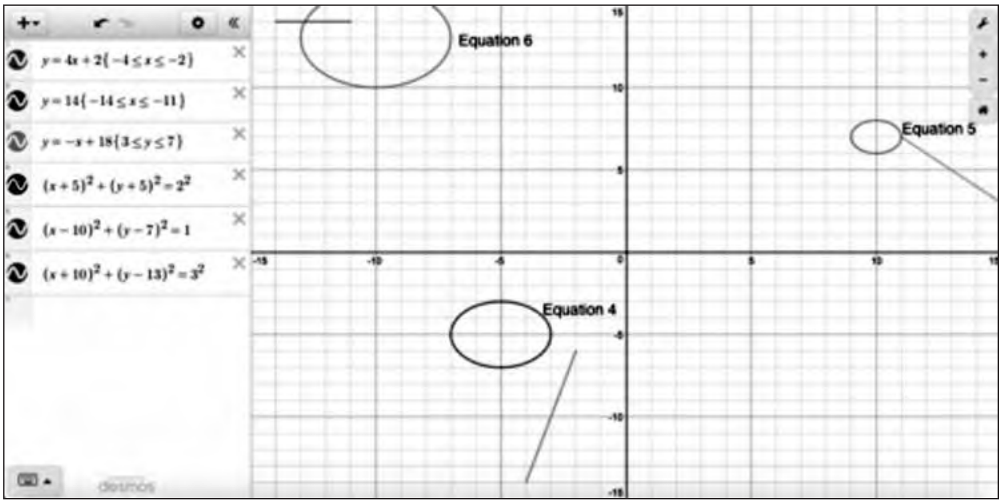

Figure 3. Example of three guesses.

Since, it is minus h and minus k in the equation of a circle that a centre that uses positive x or y values will be subtracted in the equation of a circle, while a centre that has negative x or y values will end up being added. At this stage, students were not shown where the equation of a circle comes from. This information was provided after the Desmos Battleship activity had concluded. Students were shown the following Khan Academy video to support the theoretical elements of the activity that they had engaged in: https://www.khanacademy.org/math/geometry/hs-geo-circles/hs-geo-circle-standard-equation/v/radius-and-center-for-a-circle-equation-in-standard-form

This video demonstrated how the equation of a circle can be derived using the Pythagorean theorem, and as follow-up the discussions had by students supported their observations and experiences, from both the game interactions and the viewing of the video.

In Figure 3, the circles labeled equation 5 and equation 6 respectively sunk two ships, whilst the circle labeled equation 4 was a miss. Note that if conducting this activity with students and/or pre-service teachers that they should be advised that multiple circles (i.e., more than three) should be used given it may be difficult to locate the ships of other teams.

For the purposes of conducting this activity, each student had access to a computer when playing the game. Roles were assigned to team members such that one student on each team kept track of their team's ships, and the other team's guesses; and a second player on each team kept track of each person's guesses for the location of the ship. By recording this data, students' could visually see where they had guessed and try to determine the best place for their next guess. After explaining and demonstrating the battleship interface to students, and how best to track the data to be recorded, teams and individuals were in a better position to decide on how best to keep track of their Desmos screen and the possible moves that could be made.

Observations of the students' game play

Overall, the students enjoyed the game and did a fairly good job in selecting linear equations as ships and selecting their circles. The teams tried to pick the centre of their circles based on where they visualised the circle to be. There were a few times when there was overlap between circles as is the case in Figure 4. In discussing strategy after playing the game, a few students shared that they asked the other team if they were close if it was a miss. If they knew that they were close then they realised that overlapping circles could be a good strategy to implement. Some teams were also able to hit two ships with one circle as is shown with the circle labeled equation 7 in Figure 4. One team shared that a good strategy would be to have two ships close together because the other team might only get one of the ships and then think the other ships had to be more spread out. This can backfire though if both ships are sunk with one circle.

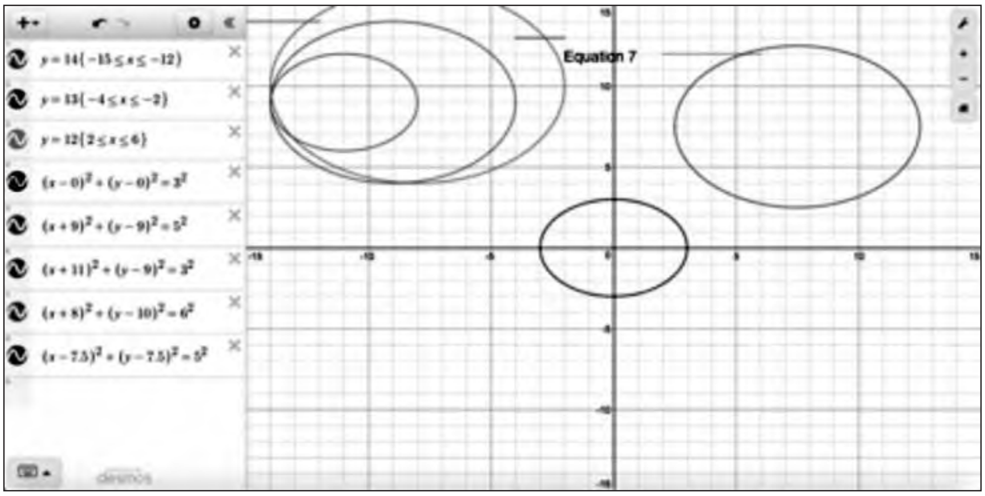

Figure 4. Example game play of a finished game.

By using Desmos, students were able to get instant feedback on their equations that they entered. Meyer and Danielson (2016) note the importance of feedback with technology. Through Desmos students can receive instant feedback based on the equation they enter, and can revise as necessary if it does not match their thinking or correct their thinking if the equation was inputted correctly but the graph did not match what they expected. Feedback in this form can encourage students to persist as they interact with the technology.

After students had played the game, an alternative challenge was shared with them to consider another strategy that they could use to make their ships harder to sink. Figure 5 shows three equations with different slopes but the same domain interval. Students were able to state the similarities and differences in the three equations, and see that a slope closer to zero lead to a ship with less length. This could also be a time to work with the Pythagorean theorem if you wanted students to find the actual length of the ships to compare them precisely.

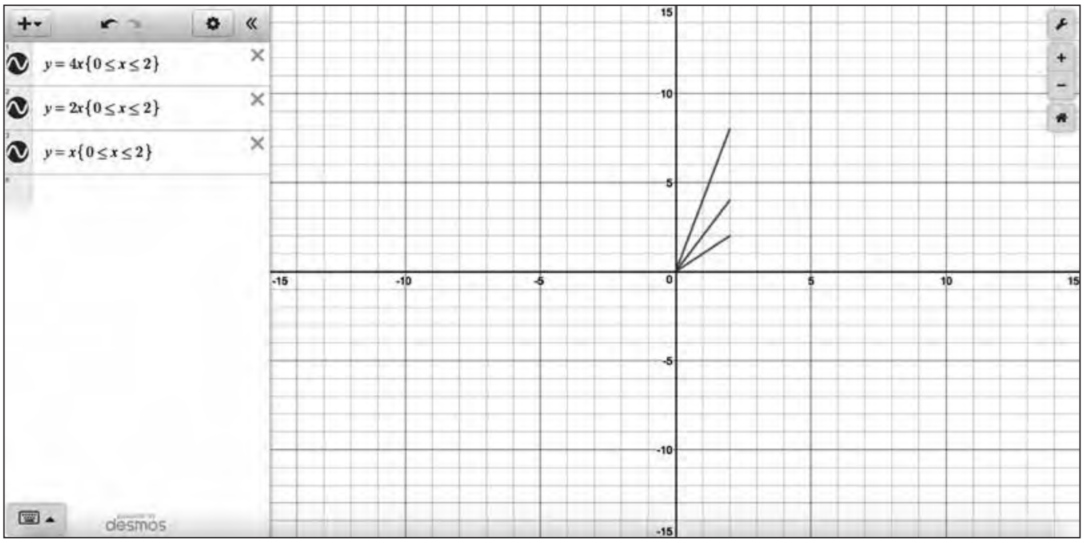

Figure 5. Ships of different lengths with the same domain interval.

Conclusion

There are many great purposes for using technology in the classroom: engage students in discovery and exploration, promote higher-level thinking, enable students to engage in real-life applications of mathematics, prepare students for the demands of this century, improve students' visualisation, and make mathematics more engaging and fun (Soucie, Radović, & Svedrec, 2010). The last two purposes identified by were particularly evident when conducting this activity with both the pre-service teachers and the Year 7 and 8 students.

Through a game-based activity students were assisted to develop skills in visualisation of linear equations and the equations of circles, in order to predict what the resulting graphs would look like. Students were actively engaged, and challenged whilst interacting in this activity. Feedback and informal observations clearly indicated that the students enjoyed using the technology in a creative hands-on way to learn mathematical concepts, and to apply their knowledge and understanding of these.

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