

## Cartes Summary

In calculus, we study how functions change. Equations give us a way to algebraically understand this change and graphs give us a geometric interpretation. However, many of our students have weak intuition for the connection between equations and graphs.

Professor James S. Rolf and I created a video game to help build that intuition. Cartes is a two player game on a Cartesian grid. The players start by placing square tiles called traps. Then they eliminate their opponents' traps by sending curves through the grid.

Once the traps are placed, each player is dealt a hand of cards containing simple equations that they can add/subtract, multiply/divide and compose to create all sorts of curves. A curve will eliminate any trap it hits, so players need to take care to avoid their own traps while targeting their opponent's. The game runs on a chess clock, and players take turns until one player has no more traps or time runs out.

We tested Cartes in three small focus groups last fall and piloted it in two of the spring sections of Math 112 (Calculus I). The feedback is encouraging. Three features stand out that make Cartes a successful learning tool.

(1) Students receive immediate feedback. As students play cards, the curves update in real time. Numerical sliders on the cards allow students to adjust parameters and see how they impact the graph.

*"Once I started playing, I started making patterns ... like a pre-picture in my mind."*

(2) Students engage in peer instruction. They discuss strategy and react to their opponents' choices. Most importantly, they have someone to talk to when confronted with misconceptions.

*"I definitely would love to play this with people outside of the class. I think it's just fun."*

(3) Students can be creative. Knowledge of curves and geometric transformations helps them develop strategies.

*"The curves, like, matter to you."*

The Yale Center for Teaching and Learning funded the project and PreviewLabs, a rapid prototyping company, helped us create the game. We also received advice about the design process from Dr. Lynn Fiellin and Dr. Kimberly Hieftje in the Yale Center for Health and Learning Games.

\*Quotes from students who participated in our fall 2016 focus groups.