Students' Understandings of Rate of Change Through Engagement with Desmos' Function Carnival

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Literature

- Conventional middle school curriculum delays students access to the "mathematics of change and variation". (Roschelle et al, 2012)
- One way is to provide students access to "MathWorlds".
- "MathWorlds" allows students to engage with dynamic graphs, directly manipulate graphs, and the qualitative reasoning about the relationships among height, time, and rate of change.
- "MathWorlds" provide tools for students to engage mathematical conversations and develop conceptual understanding. (Roschelle Kaput, 1996)

Framework

Why Piecewise Functions?

- Students can draw upon pre-existing knowledge and skills. (Roschelle et al, 2012)
- Students can compare rate of change through different components of the function.

Mathematics of Change and Variation (MCV)

- Complexity to simplicity to build conceptual understanding. (Duckworth, 1991)
- Graphical approach puts the real world phenomena at the center of the task.
- Foundational experiences can lay the ground work for more advanced topics such as acceleration, continuity, and limits. (Roschelle et al, 2012)

Data Collection

- 7 seventh grade classrooms in the southeastern U.S.
- Students worked in pairs on Function Carnival
- A total of 22 pairs of students completed the task
- Worksheets, screen recordings, and audio were collected for each pair
- For each screen cast, we created a narrative that included a chronological record of the students' engagement with the task that included a transcript as well.

Analysis

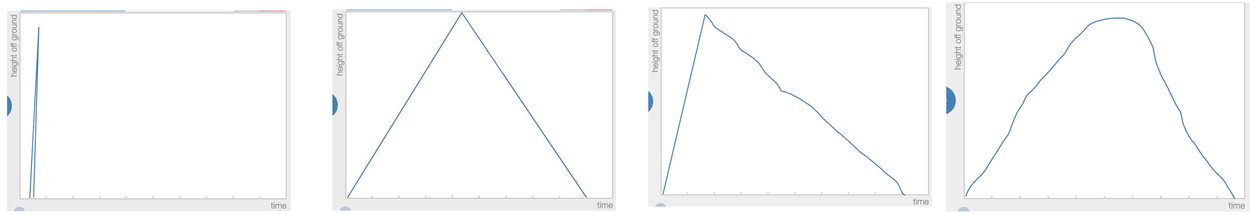
- For each type of data, a codebook was developed.
- All data was coded by two researchers. Disagreements were discussed and discrepancies were resolved.
- Initial graphs
- We coded each graph for the shape of the graph
- Narratives
- We coded for elements of rate of change they demonstrated

Research Question

What understandings of rate of change do middle school students demonstrate through engagement with function carnival?

Results

Cannon Man



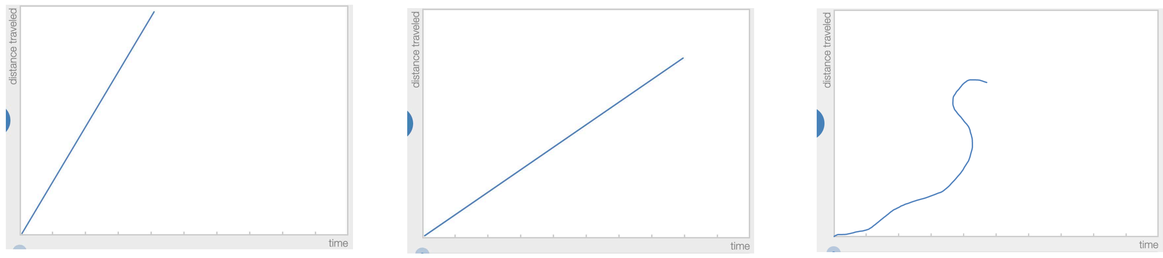
Straight Line 0%

Pointed Symmetric 37%

Pointed Skewed 14%

Curved 19%

Cars



Straight (Steep) 32%

Normal Incline 23%

Curved 14%

What understandings of rate of change did they demonstrate?

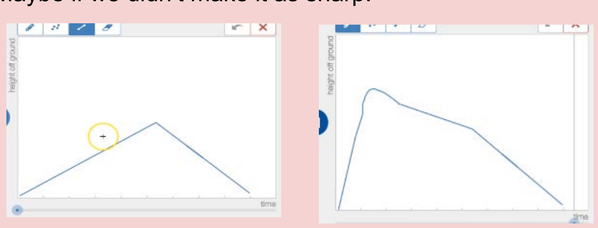
Cannon Man: Pointed vs. Curved
"His cannon man will go faster because his peek is sharp. He needs to make his peek less sharp and more round." 20%

Cannon Man: Change with Parachute
"The graph shows that when the parachute opens the graph at the end curves down." 20%

Cars: Straight line Means Stop
"The car slowly goes up but the end is completely straight so it doesn't move but time is still going." 13%

Cars: Shape of the Line Affects the Speed
"When you go lower it goes slower and when you go higher it goes faster." 63%

Cannon Man: FC_M77_M78
"See see see, our ending is good. Our beginning needs to go higher."
"You have to match the height to the time."
"Maybe if we didn't make it as sharp."



Cars: FC_M79_M93
"If we go down then it's going to go backwards, if we go up, it's still going to go forwards. We need like something to keep it still."
They also recognized that the line going up represents "how fast and the time."

Function Carnival Task

- Desmos task where students qualitatively draw the graph for three scenarios: cannon man, cars, and ferris wheel.

- The students had to answer the following prompts for its designated simulation:

Q4. How did you represent Cannon Man being shot out of the cannon on your graph?
Q5. How did you represent Cannon Man falling back down and his parachute opening on your graph?
Q9. What is something you noticed about the car's motion and how did you represent it on your graph?
Q13. What is something that you noticed about your cart's height from the ground and how did you represent it on your graph?

Implications

Cannon Man

- No students demonstrated a vertical line for the movement of the cannon man, which majority of teachers expected.
- Students were not able to initially represent the change in speed of the cannon man on the descent.
- After trials, 20% of students realized that the point of the graph needed to be curved instead of pointed, and 20% of students realized that the shape of the line changed when the cannon man's parachute opened.

Cars

- Unlike cannon man, 14% of the students initially drew the shape of the track rather than the movement of the car.
- Initially none of the students were able to represent the car crashing.
- Majority of the students figured out that the shape or steepness of the line affected the speed of the car.
- However, 13% of the students realized that the straight line means the car would stop because distance does not change as time continues.