



# THE UNEXPECTED CONSEQUENCE OF INCREMENTAL DESIGN CHANGES

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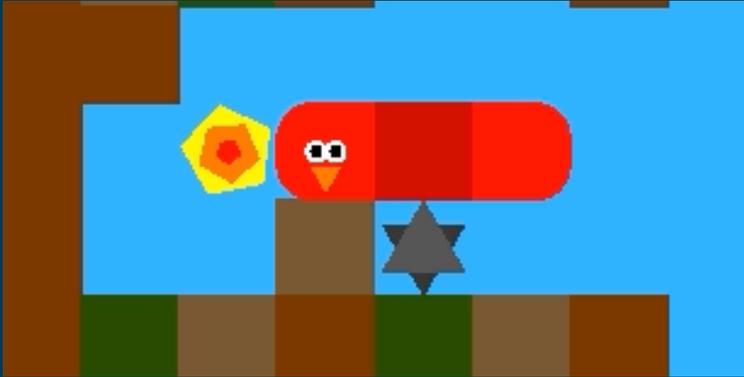
Nicolas Decroocq, ESM Saint-Cyr

Aaron Tripodi, University of Alberta

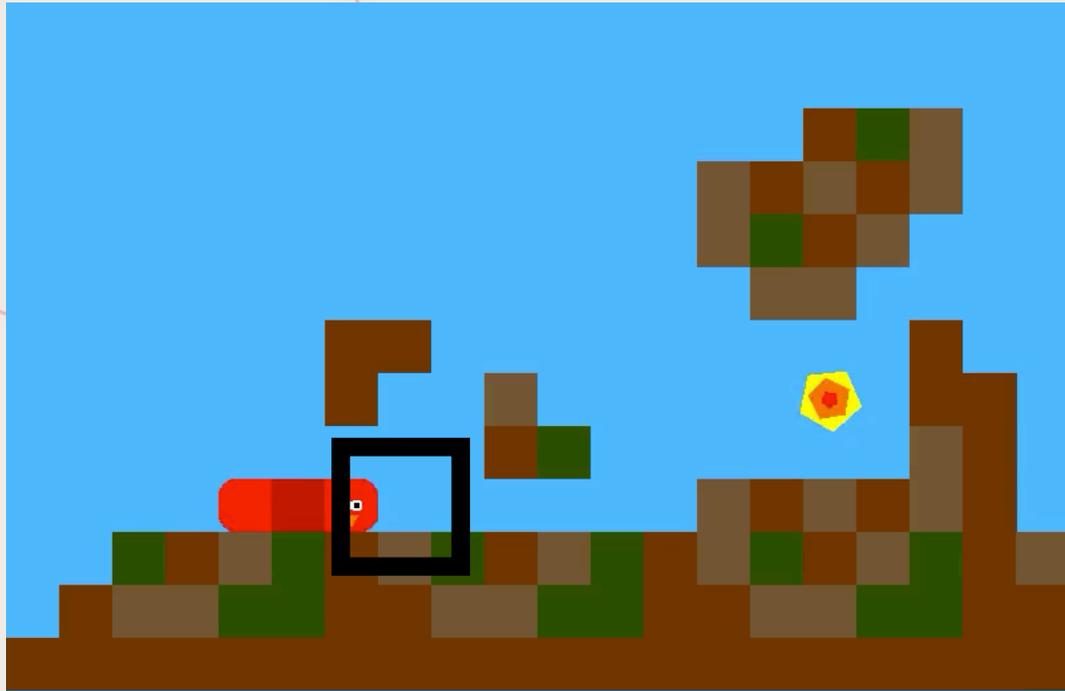
Matthew Guzdial, Amii Fellow, University of Alberta



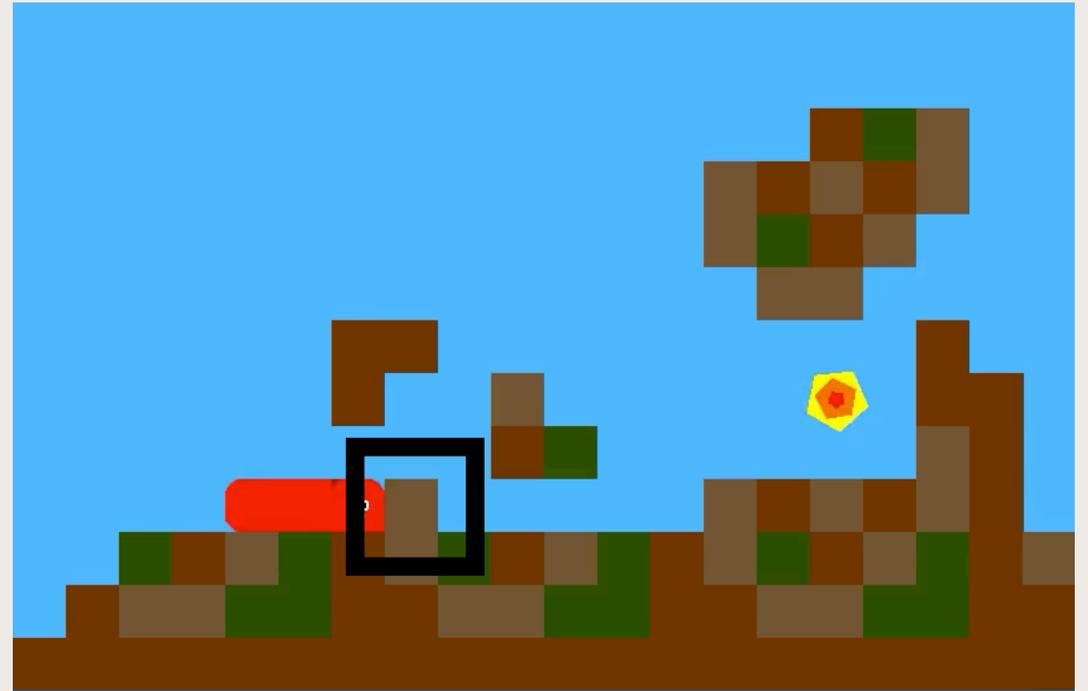
# GAME RULES



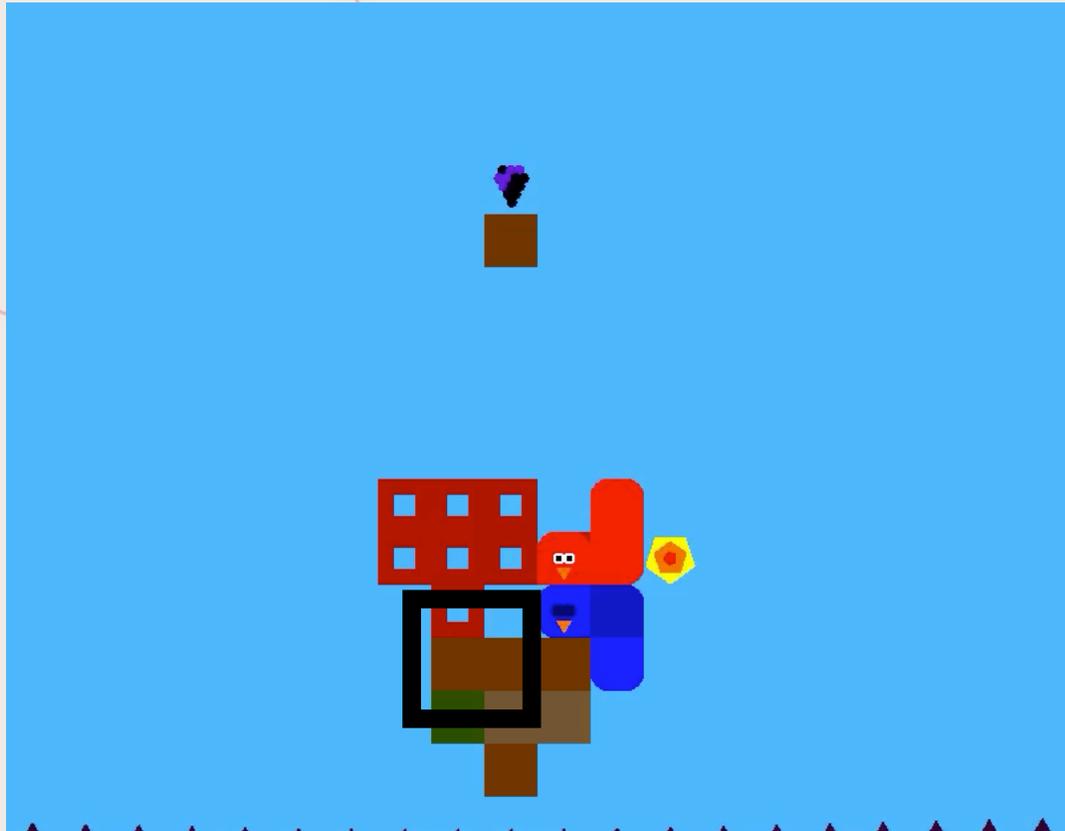
1. The goal of the game is to get your snakebird into the exit.



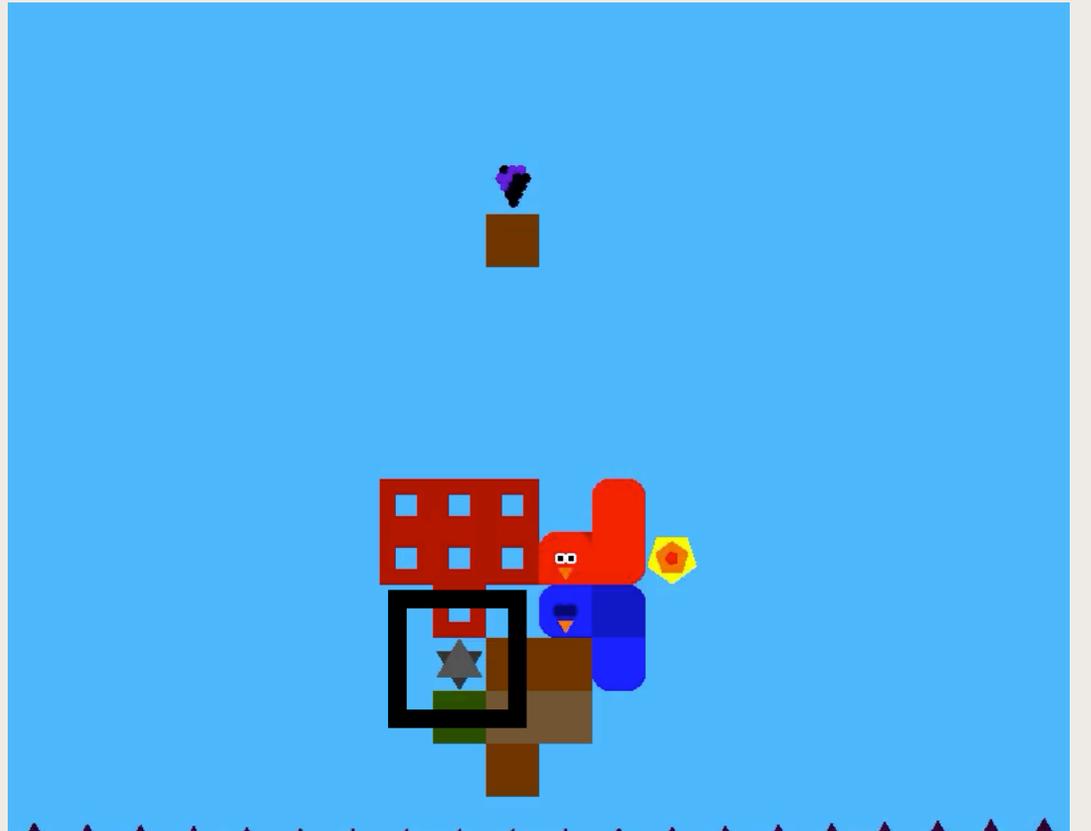
Snakebird Primer Level 0  
Solution length: 12



Solution length: 14

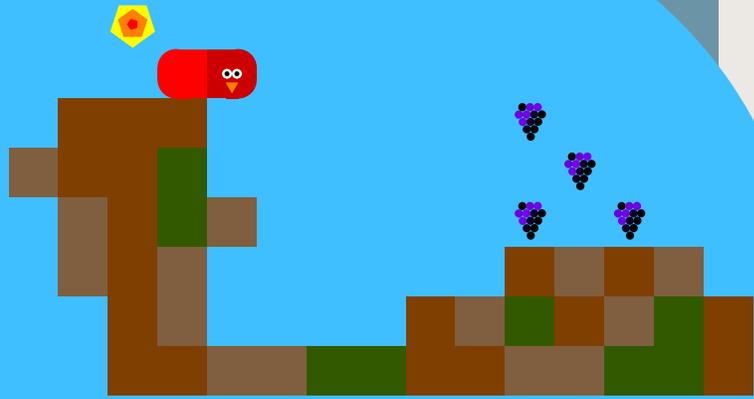


Snakebird Level 24  
Solution length: 27



Solution length: 58

# INCREMENTAL DESIGN CHANGES



Snakebird Primer Level 2  
Solution Length: 28

**Exhaustive PCG (EPCG) in Snakebird**

**Find 1-step change that maximizes the solution length**

**Players found the resulting levels more interesting and challenging than the original levels**

# SELECTED RELATED WORK

## PCG for Sokoban level generation

(Khalifa and Fayek, 2015; Bento, Pereira, and Lelis, 2019)

## ASP for Refraction Puzzles

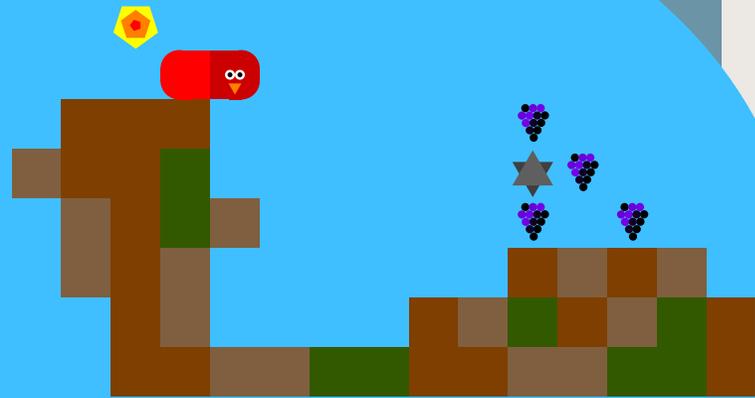
(Smith, Butler & Popovic, 2013)

## Angry Birds

(Ferreira and Toledo 2014; Stephenson and Renz 2016; Jiang, Harada, and Thawonmas 2017)

## Search-Based PCG (GA) for Baba is You

(Charity, Khalifa, and Togelius 2020)



Snakebird Primer Level 2  
Modified Solution Length: 41

# EXHAUSTIVE PCG

Requires a generator G & evaluator E

G: Generator generates all content

E: Evaluator evaluates content

Return the "best" content



# EPCG IN SNAKEBIRD

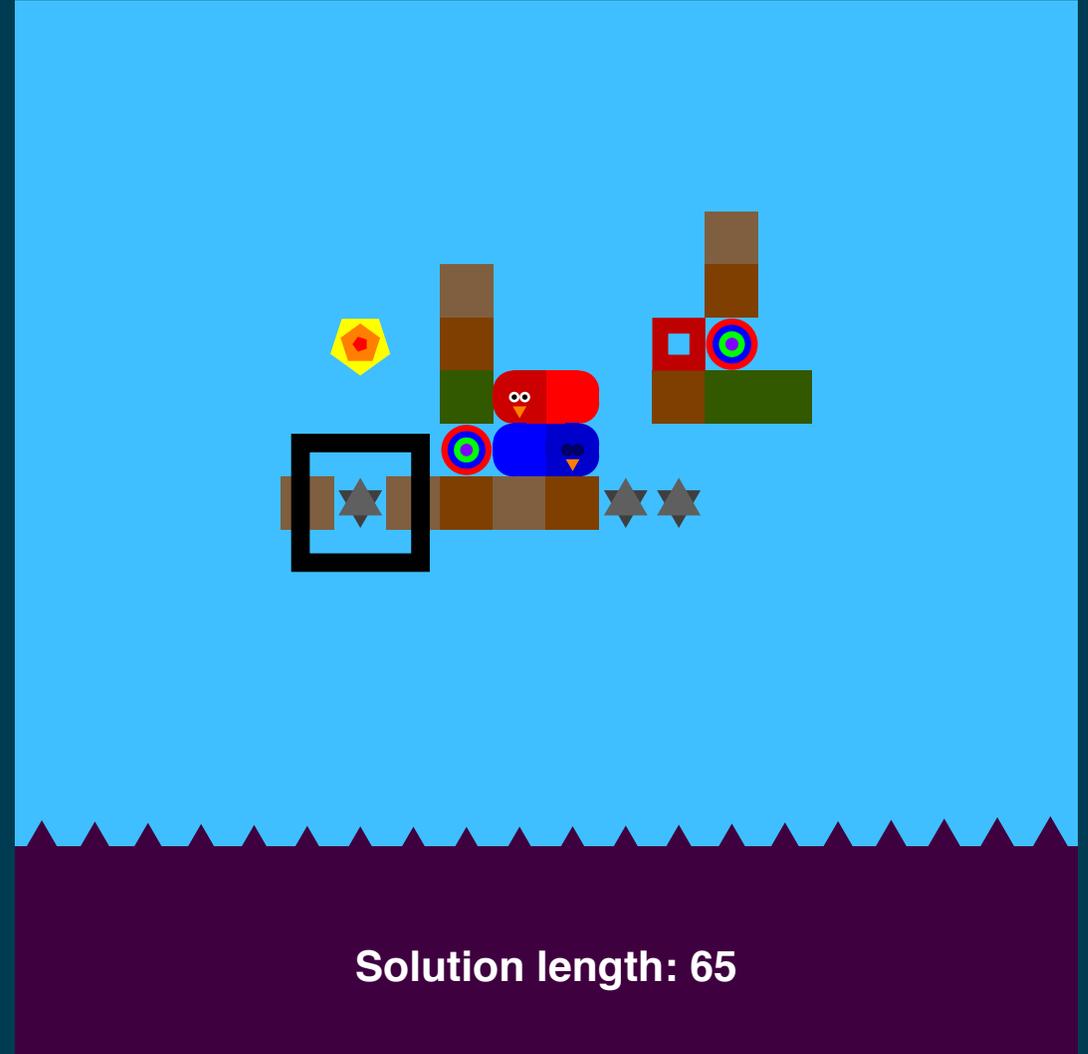
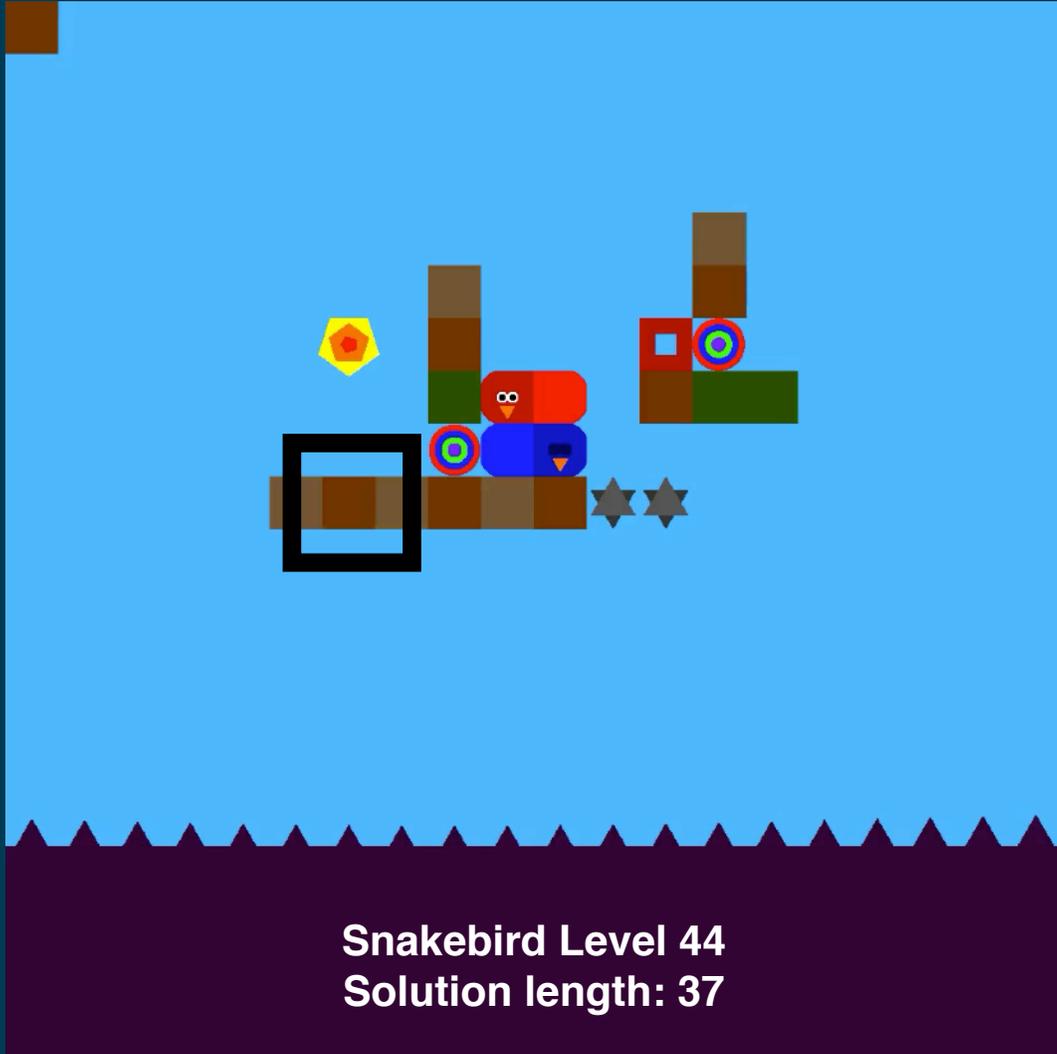
**G: For all locations** (width x height)  
**Change tile to sky/ground/spikes**  
**Ignore fruit, exit, snakebird**

**E: Perform Breadth-first search**  
**Measure optimal solution length**  
**Can choose min or max**



Snakebird Primer Level 37  
Modified Solution Length: 28

# INCREMENTAL EPCG EXAMPLE



# ANALYSIS

## Snakebird

46 regular levels

6 difficult (star) levels

1 black hole level

## Snakebird Primer

69 regular levels

6 difficult (star) levels

1 black hole level

**108 of 129 levels easily solved**

A screenshot of Snakebird Level 36. The scene is a 2D platformer level with a light blue sky and a dark purple ground. The player's snake is composed of red, blue, and yellow segments, positioned on a brown platform. To the right, there is a yellow flower-like power-up and a series of grey stars. The level is filled with various brown and green platforms and obstacles.

Snakebird Level 36  
Solution Length: 30

# RESEARCH QUESTIONS

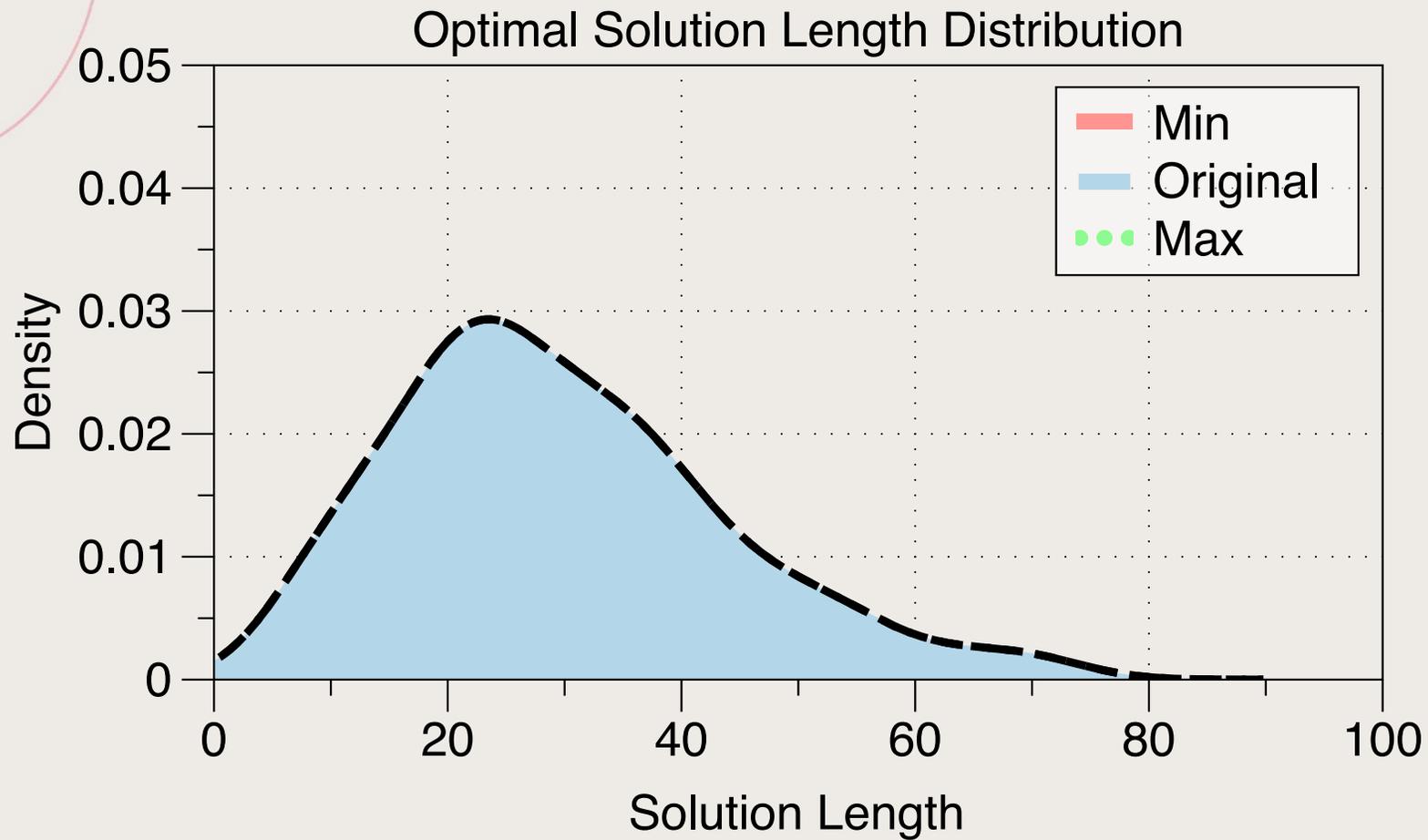
**Does incremental EPCG lead to levels that are significantly different?**

**Do humans find the resulting levels interesting?**

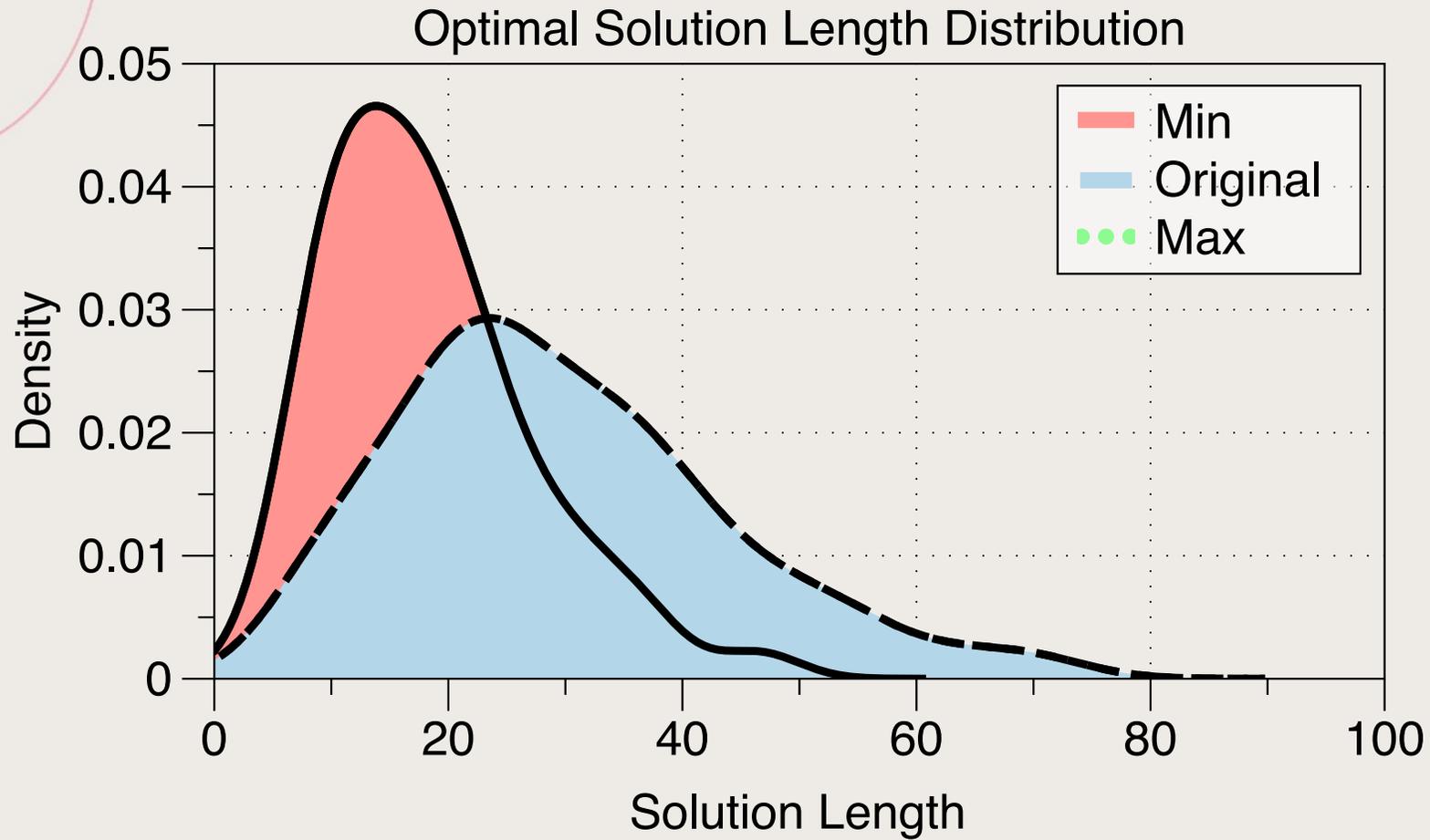
A screenshot of the game Snakebird Level 36. The scene is set against a light blue sky and a dark purple ground. The ground is composed of various colored blocks (brown, green, red, blue) and a series of grey stars. A yellow flower is visible in the upper right. A red snakebird is positioned on the left, and a blue snakebird is on the right. A red circle with a white outline is on the ground. The text "Snakebird Level 36" and "Solution Length: 55" is displayed in the bottom left of the image.

Snakebird Level 36  
Solution Length: 55

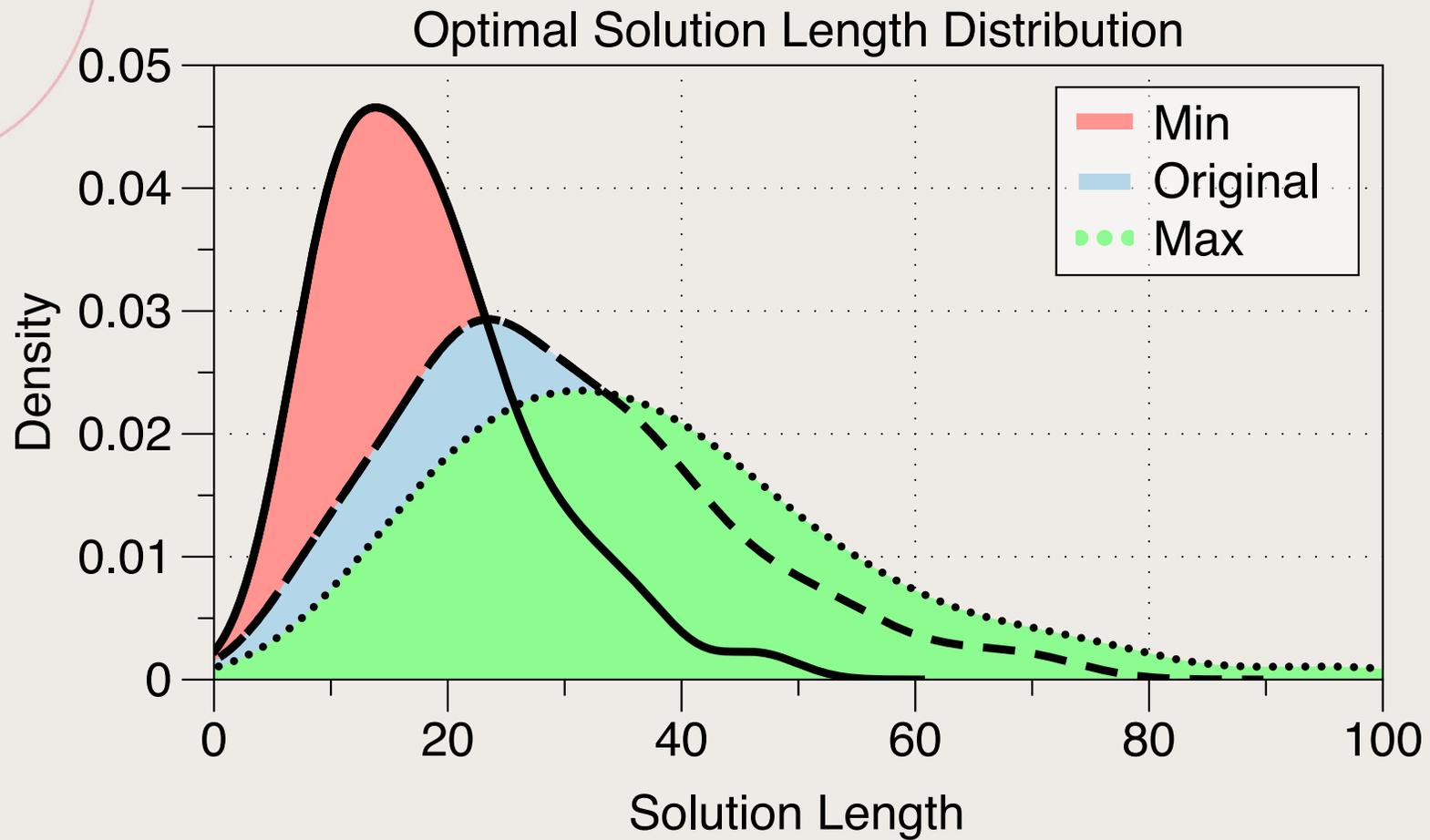
# DISTRIBUTIONS



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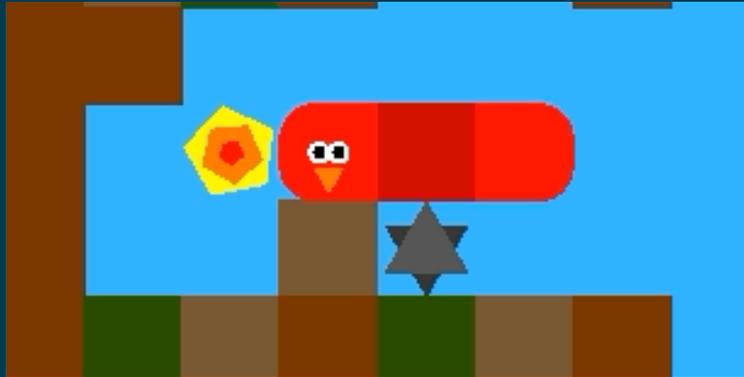
# DISTRIBUTIONS



# USER STUDY (ANHINGA)



CC BY 2.0; Tim from Ithaca



1. The goal of the game is to get your anhinga into the exit.

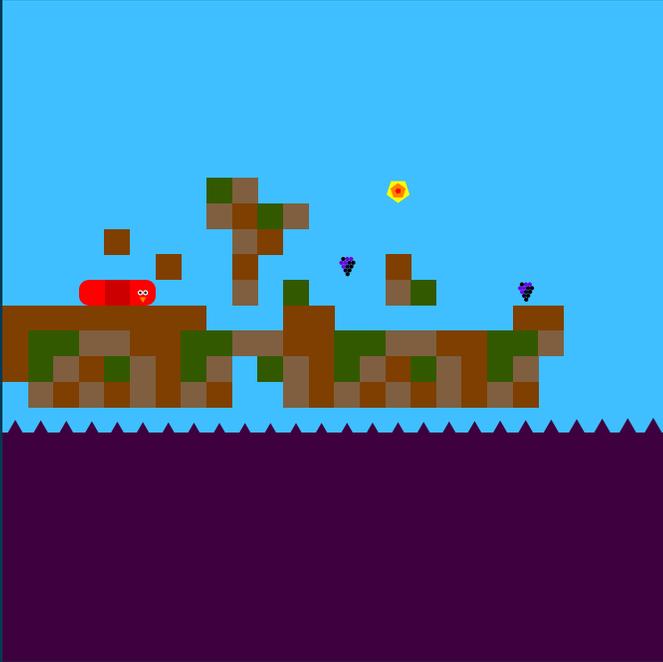


2. Before you can exit, you must eat all the fruit in the level. Eating fruit makes your anhinga longer. *(Note that your anhinga can stand on top of fruit!)*



3. Be careful not to fall on spikes, as this will kill your anhinga. But, if you do, the game will undo your move so you can try again.

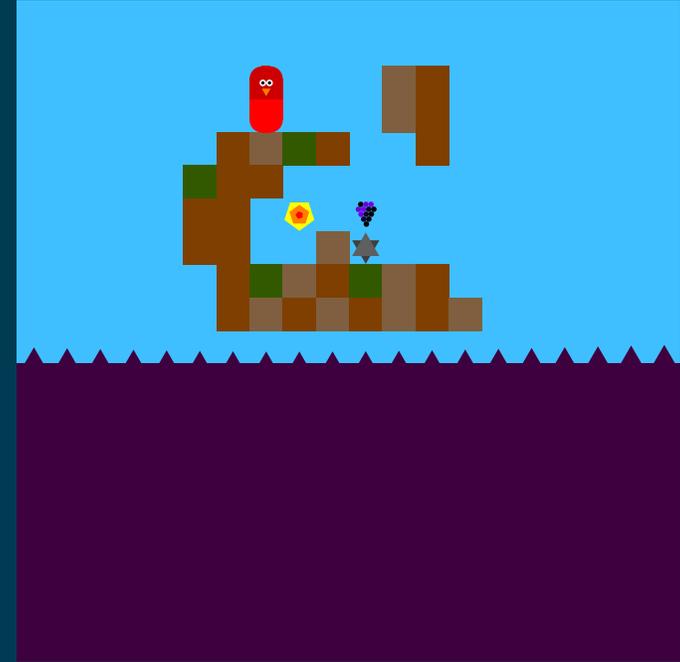
# USER STUDY



Snakebird Level 0



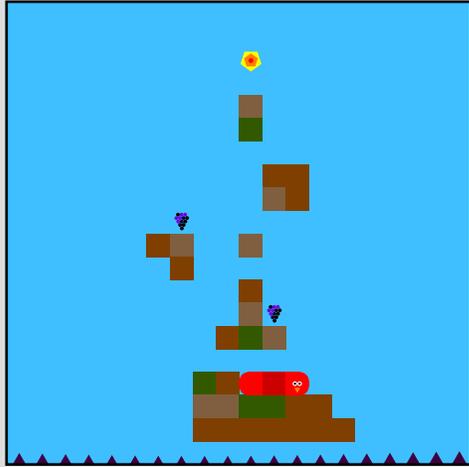
Snakebird Primer Level 4



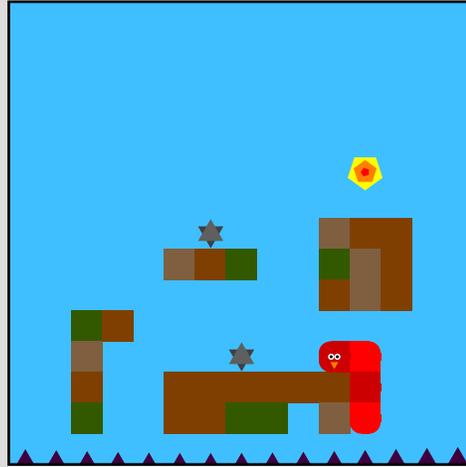
Snakebird Primer Level 5  
*(modified to teach spikes & standing on fruit)*

# USER STUDY

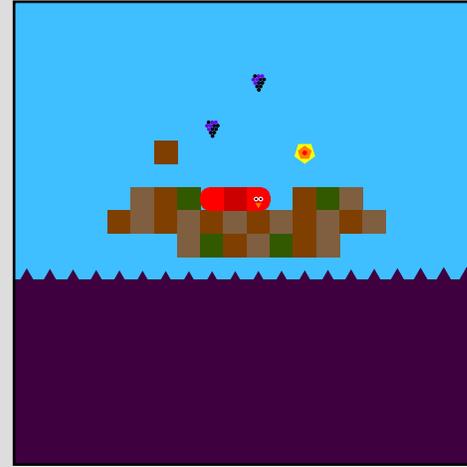
Before EPCG



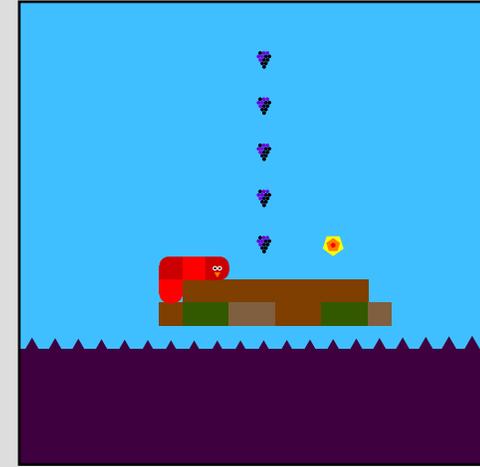
Snakebird Primer 7



Snakebird Primer 19

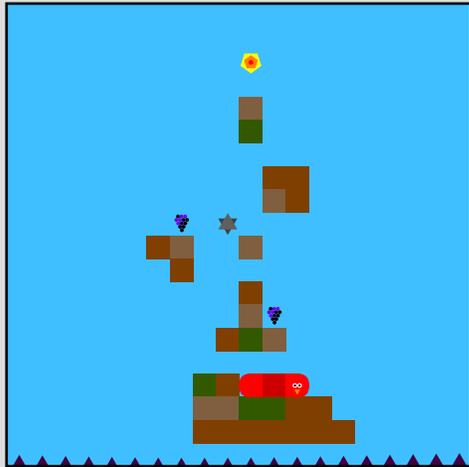


Snakebird Primer 26

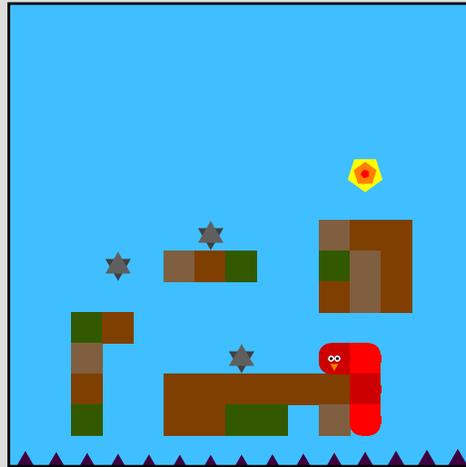


Snakebird Primer 28

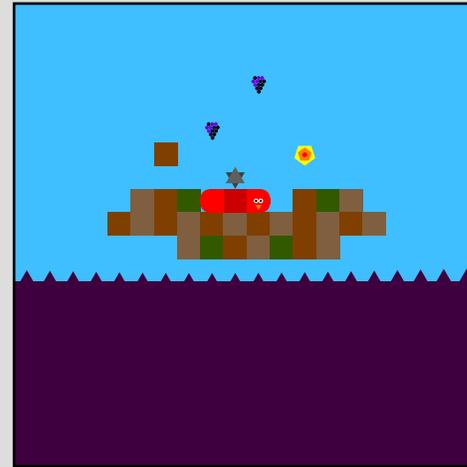
After EPCG



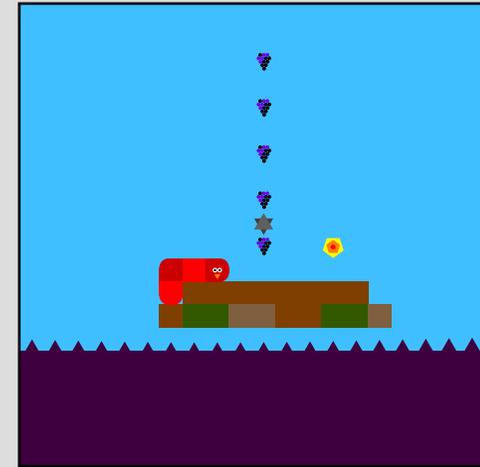
Snakebird Primer 7



Snakebird Primer 19



Snakebird Primer 26



Snakebird Primer 28

# SURVEY QUESTIONS

**For level pairs:**

- **Which of the levels was most \_\_\_\_\_ to play?**
  - *fun, frustrating, surprising, challenging, interesting*
- **Overall, which of the levels did you most enjoy?**

**Across all four levels, what level did you think was best?**

# SURVEY RESULTS

Is EPCG variation more:

Fun	Surprising	Enjoyable	Interesting	Frustrating	Challenging
48.3	48.3	55.0	61.7	61.7	63.3

$p < 0.05$

Which level is best?

65% EPCG Variant ( $p \ll 0.05$ )

35% Original Level

# LIMITATIONS

**Levels are not necessarily better**  
**Have to be put in context of game**

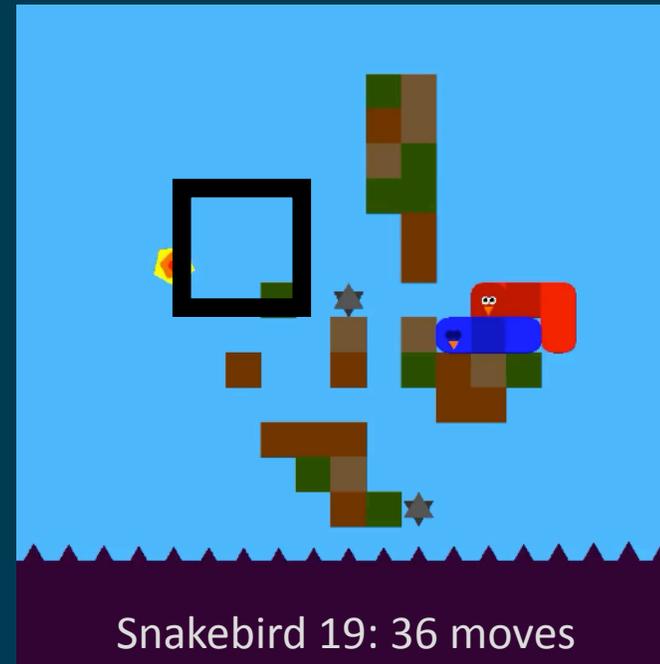
**Evaluator maximizes solution length**  
**Other metrics may be better**

**Humans do not find optimal solutions**  
**Can still give humans insight**



# CONCLUSIONS

- Incremental design have a significant impact in Snakebird
  - Level analysis
  - User study
- Online demo available
  - <https://movingai.com/snakebird-editor.html>
- Working on better mixed initiative / co-creative tools



# MORE INFORMATION

- Paper:

- <http://www.cs.ualberta.ca/~nathanst/papers/sturtevant2020incremental.pdf>

- Code:

- <https://github.com/nathansttt/hog2/tree/PDB-refactor/apps/snakebird>

- Demos:

- <https://movingai.com/snakebird.html>
- <https://movingai.com/snakebird-editor.html>



# A DEMONSTRATION OF ANHINGA: A MIXED-INITIATIVE EPCG TOOL FOR SNAKEBIRD

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Matthew Guzdial, Amii Fellow, University of Alberta

