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28-29 JULY 2022
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FONDATION STaBL FOUNDATION

Teaching Interaction Using State Diagrams

McMASTER START CODING

Padma Pasupathi, **Christopher Schankula**, Nicole DiVincenzo, Sarah Coker and Christopher Anand

McMaster University

TFPIE 2017 discussion about state

data TFPIE2017Attendee = Speaker | Audience1 | Audience2 | Audience3 | …

- *Speaker:* Mumble, mumble, state, mumble mumble.
- *Audience1:* State! You cannot teach children state.
- *Audience2:* They will never understand it.
- *Audience3:* Why don't you teach them Monads, like normal people.
- *Audience4:* State is evil!

- Would it be better to have a discussion informed by evidence?
- What kind of evidence would be informative?

Padma's MSc Research Questions

- RQ1: Do grade 4-5 students demonstrate an understanding of State Diagrams by being able to translate between different representations?
- RQ2: Do grade 4-5 students demonstrate equal facility for translating between different representations of state diagrams?
- RQ3: Can grade 4-5 students understand the role of reachability? Assuming that students who did not understand the role of reachability would generate random graphs, what confidence do we have that the graphs are more reachable than random graphs?

Padma's MSc Research Questions (Cont'd)

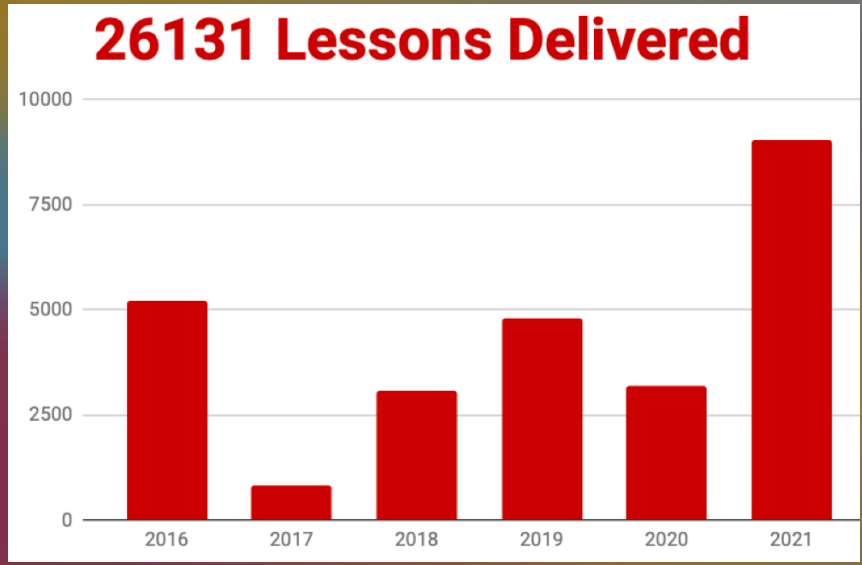
- RQ4: Are grade 4-5 students engaged by state diagrams and their applications to adventure games?
- RQ5: Do grade 4-5 students understand abstract and concrete states equally well? Will students presented with concrete states generalize to abstract states without prompting?

Background Research

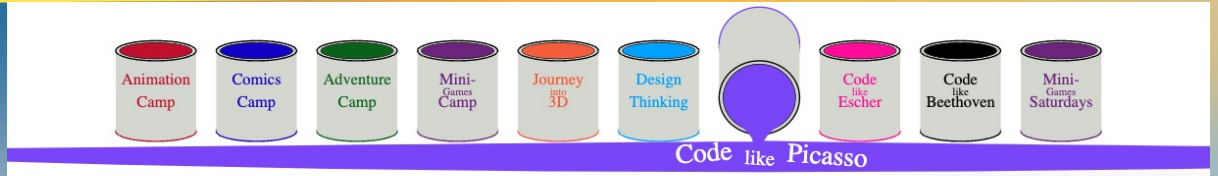
- Computer science is as important as English and should be taught in the elementary schools [Goldenberg and Carter, 2021]
- Event-driven programming (EDP) and state diagrams is an effective way to teach beginners coding, as it focuses on behavioural characteristics of how users use software [Lukkarinen et al., 2021].
- Students who learned through drawing scores higher than students learned through text-based comprehension [Schmeck et al., 2014].
- Learning through drawing helps in taking different perspectives and expose to other domains like maths and literature when working in groups [Park et al., 2020].

McMaster Start Coding: 26131+ Lessons Delivered

- Grades 4-8 (and beyond)
- We <3 Elm
- Run by undergrad, high school and graduate student mentors
- Over 1000 classes and 26,000 students visited in past 5 years



Depth = Summer Camps



Click to book:

- **July 5-9**
- **Aug 9-13**

Click for poster:

What to expect during the camp

- You will work individually or in a team to create pictures, animations or even interactions in the style of a famous painting or artist.
- You will learn the history of art in half an hour.
- You will answer the question: "What would Picasso do with animations?"

Learning objectives

- Learn how art evolved through time
- Learn to identify important styles of art
- Learn to translate artistic ideas to a digital medium

Communication

- email with confirmation of registration
- information on registering for one free lesson (per camp)
- email with Zoom link Thursday before the camp
- daily email update with your child's progress

Click for examples:

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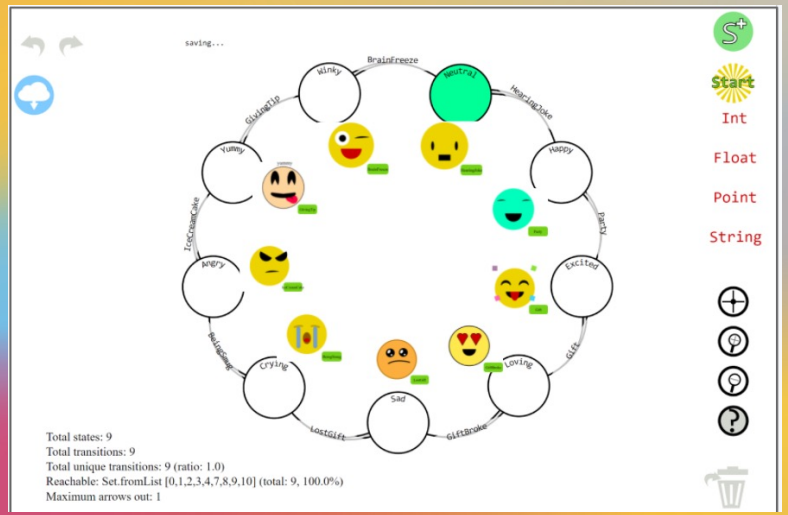
Camp Creations

https://macoutreach.rocks/share/44156f6f

https://youtu.be/7cU1c42tHqk



- Social-Emotional Learning
  - Emoji Game

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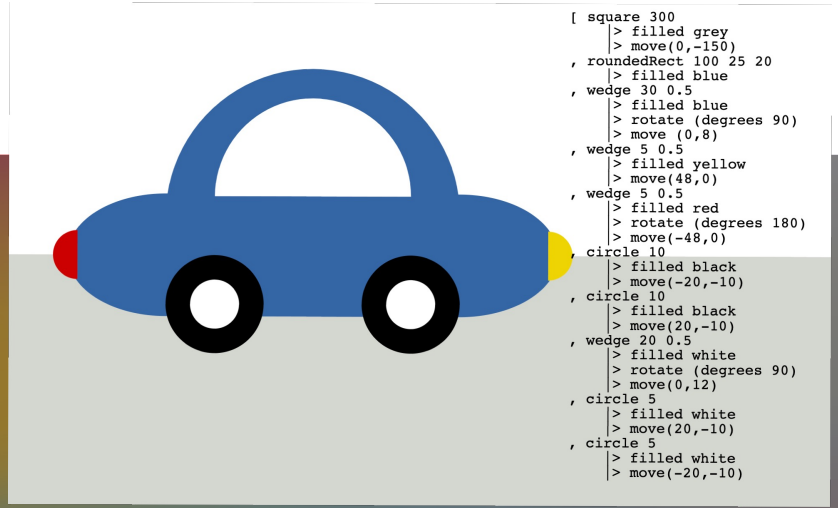
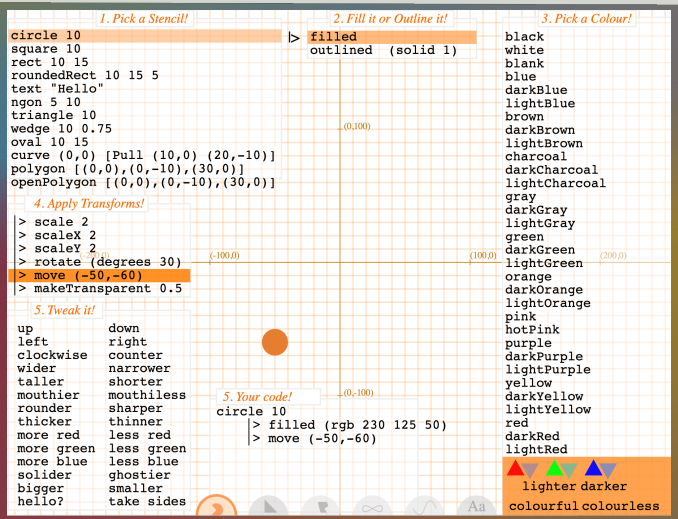
Advantages



- **Compositional Graphics Library**
  - **Less memorization, more experimentation**
  - **Easy to learn**
  - **Reinforces Primary Geometry Curriculum**
  - **Create Animations on day 1**
- Algebraic Thinking
  - Prepares *all* children for algebra opening STEM pathways
  - Functional Programming matches Algebra
  - Scratch, Python matches Recipes
- Model-Driven Engineering
  - Adapted for Teaching:
    - Teach mathematical structures first
    - Generate code automatically to accelerate learning
  - Create interactive games from scratch in week 1



Advantages

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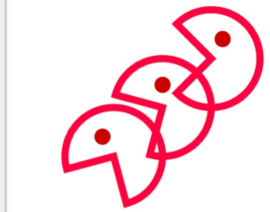
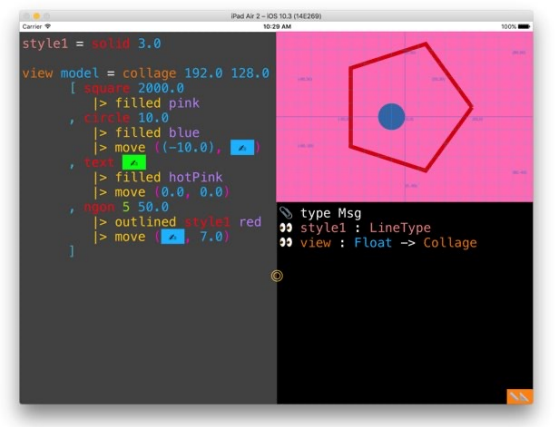
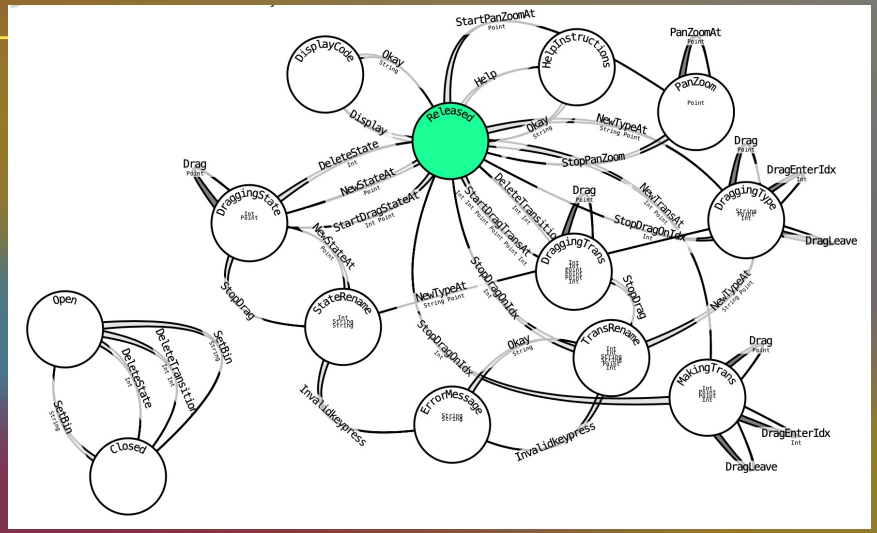
```
player =
  group
    [ circle 5
        |> filled red
        |> move (7,12)
    , wedge 30 0.75
        |> outlined (solid 4.5) hotPink
    ]

myShapes model =
  [ player
      |> rotate (degrees 30)
  , player
      |> move (30,30)
  , player
      |> rotate (degrees 60)
      |> move (-30,-30)
  ]
```



Advantages

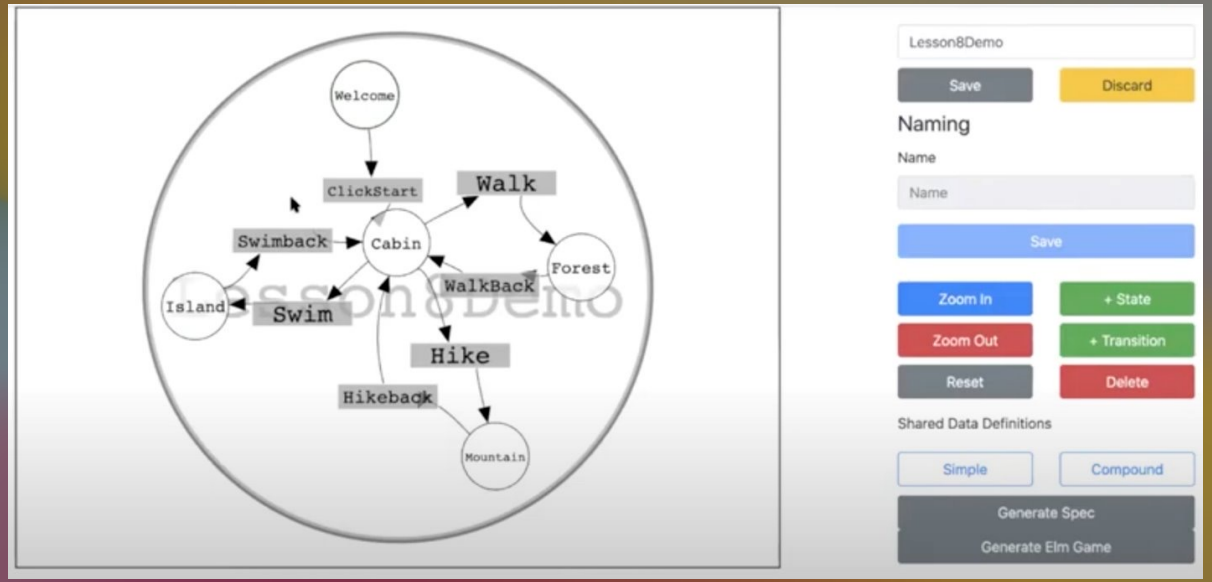




- **Model-Driven Engineering**
  - **Adapted for Teaching:**
    - **Teach mathematical structures first**
    - **Generate code automatically to accelerate learning**
  - **Create interactive games from scratch in week 1**

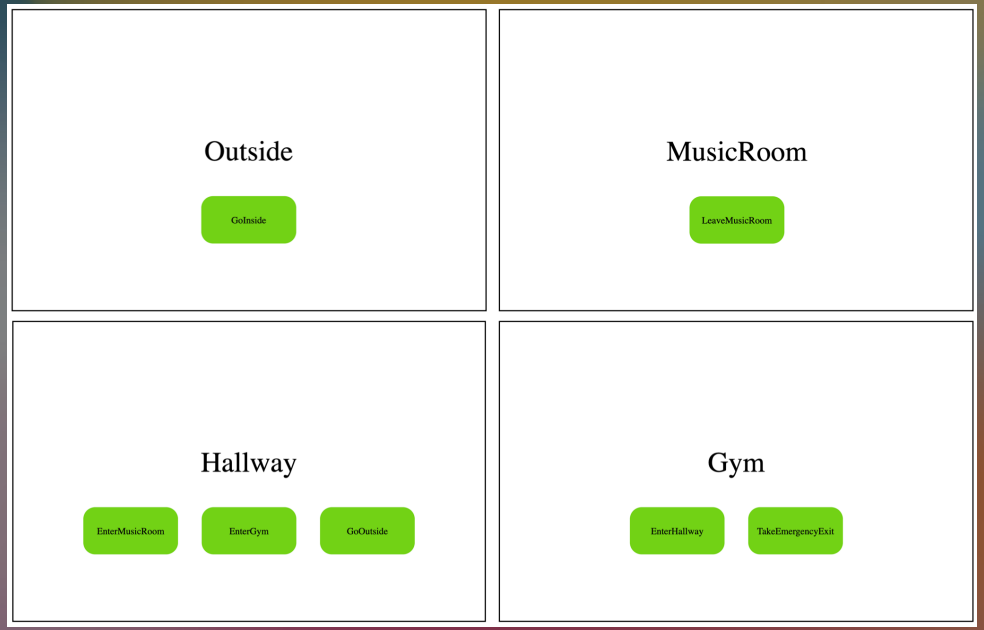
First attempt: PAL Draw

- Written for Petri App Land, an MDD experiment for distributed computation
- State Diagrams were contained in Places.
- Super clunky bootstrap interface, SD component written in two days.



… but kids loved it!

…because it generated a basic app for them, and allowed them to be creative



Challenge design

Day 1: Basics of state diagrams and lessons, group work to come up with basic adventure game.

Day 2: Challenges

Challenge 1: Paragraph explanation → State diagram

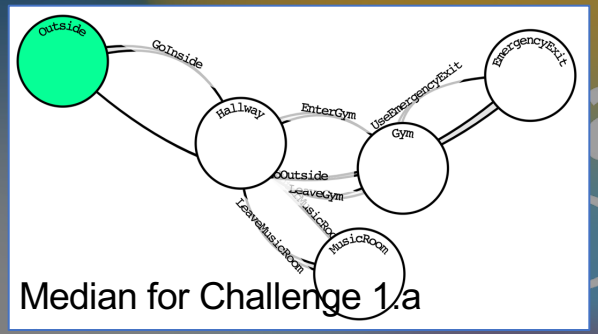
Challenge 2: Bullet point explanation → State diagram

Challenge 3: State diagram → English

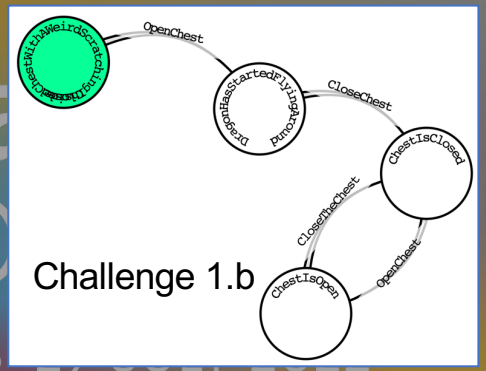
Challenge 4: Finished game → State diagram

RQ1: Do grade 4-5 students demonstrate an understanding of State Diagrams by being able to translate between different representations?

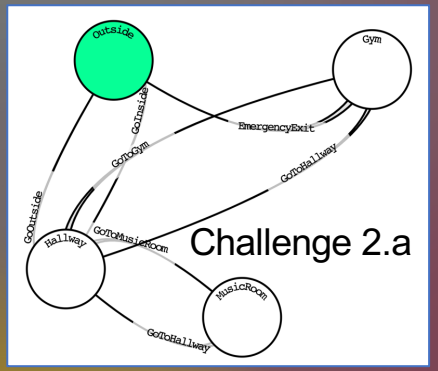
Yes, when students were given different representations and asked to convert them, most were able to do so:



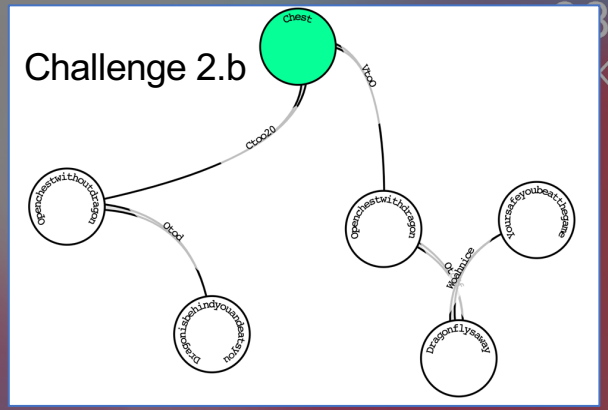
Median for Challenge 1.a

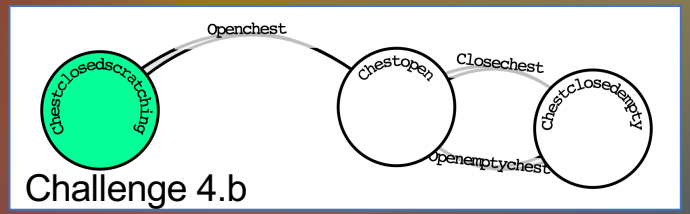


Challenge 1.b



Challenge 2.a



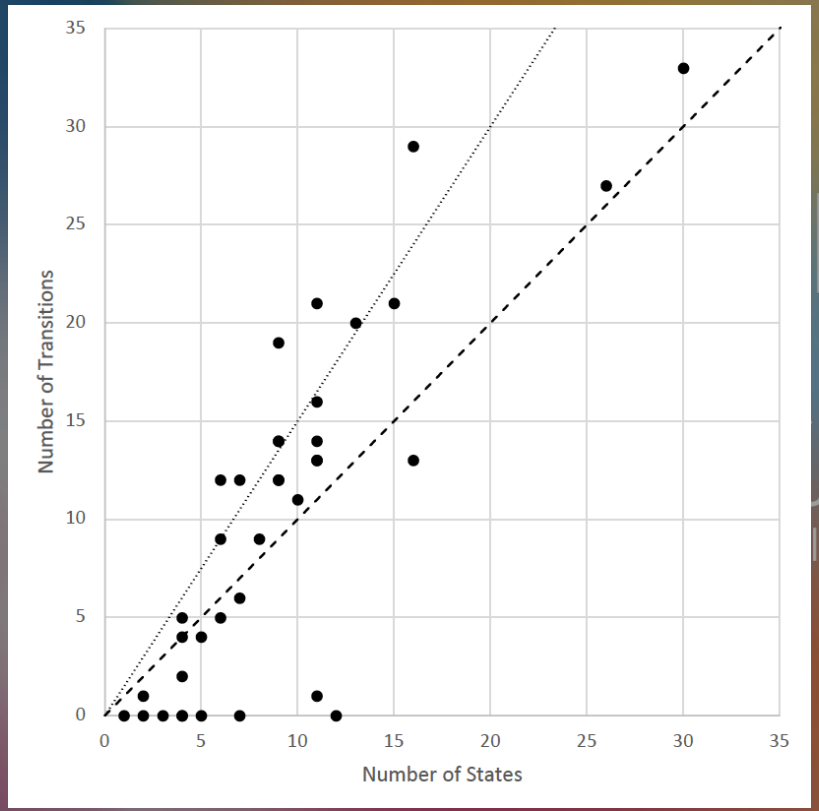


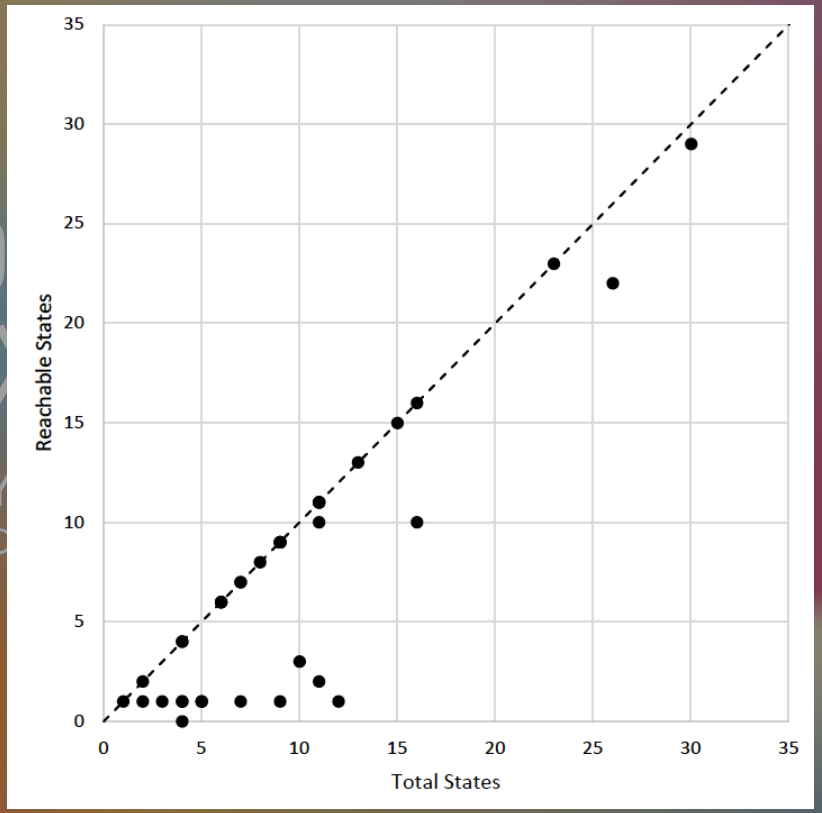
RQ2: Do grade 4-5 students demonstrate equal facility for translating between different representations of state diagrams?

No:

- Students are sometimes confused about how much to write
  - Especially in the case of a cycle in the graph, which shows understanding of the state diagram model
- Students found it easier to interpret point-form specifications rather than paragraphs.
- Students found conversion of a working game into a state diagram easiest of all.

RQ3: Can grade 4-5 students understand the role of reachability?

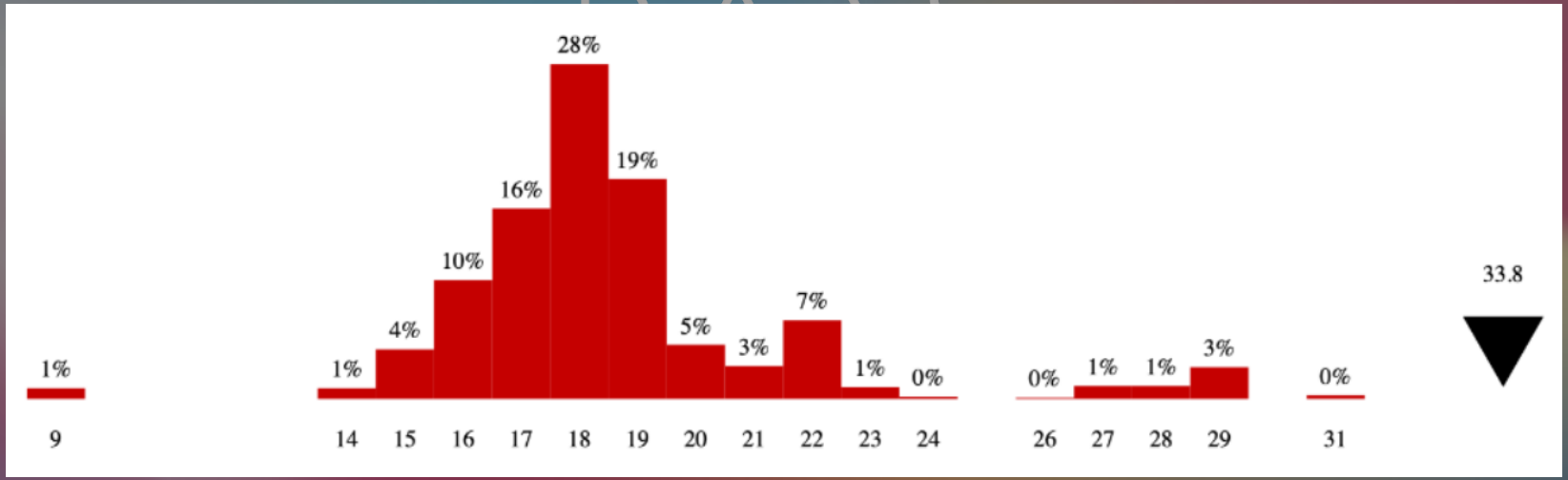




RQ3: ... Statistically significant?

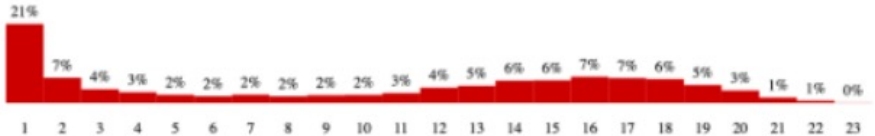
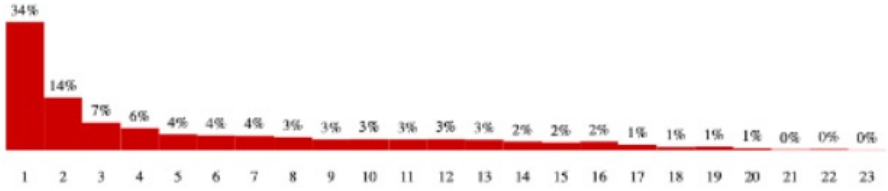
- We asked: Can grade 4-5 students understand the role of reachability? Would randomly generated diagrams be as reachable?
- Anderson-Darling: Is data X from distribution F?
  - Simulated randomly- generated diagrams
  - Compute A^2

$p < 0.001$ (only S=11)

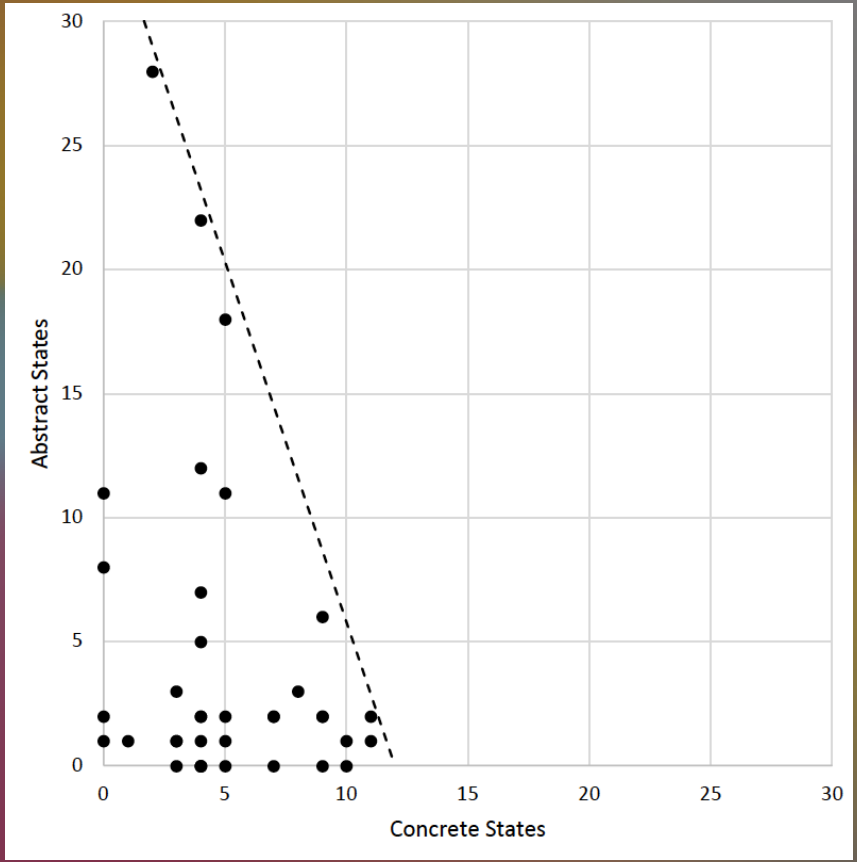


RQ4: Are grade 4-5 students engaged by state diagrams and their applications to adventure games?

- Yes!
- Many spent more time on the diagram than on the graphics.
- Several groups kept working after the class visit.

States	Transitions	Probability Distribution Function	Observed
23	38		23
30	33		29

RQ5: Do grade 4-5 students understand abstract and concrete states equally well?



Thank you!

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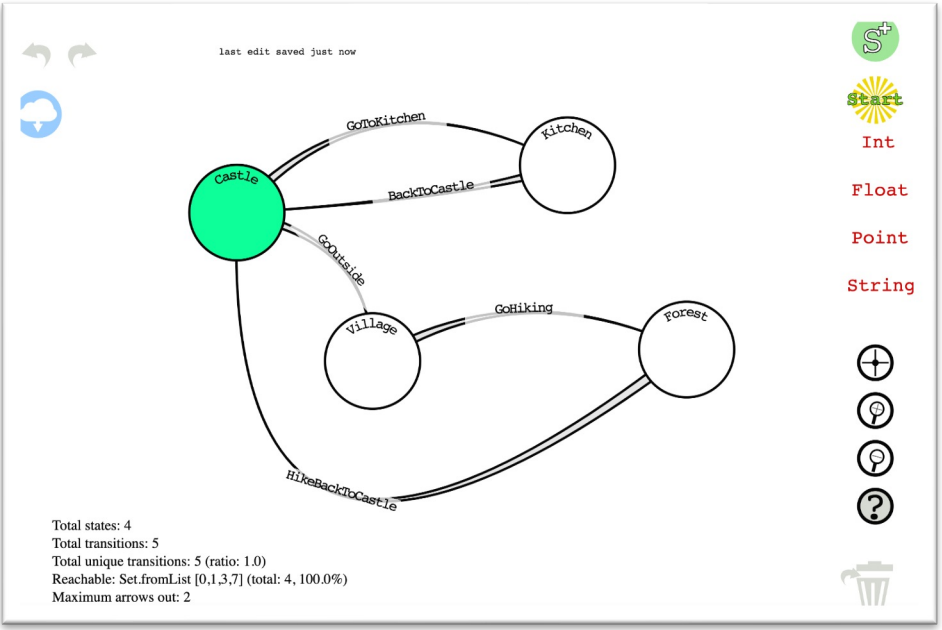
Visit us: http://outreach.mcmaster.ca, https://stablfoundation.org

Email: schankuc@mcmaster.ca;
cs4you@mcmaster.ca

The Tool



- Visual state diagram creator, written in Elm
- Generates basic Elm template from states
- Saves to a server automatically; mentors can access students' work to help them

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