Teaching Interaction using State Diagrams

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TFPIE

2022

TFPIE 2017 discussion about state

- *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!

Research Questions

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

Padma's MSc RQs

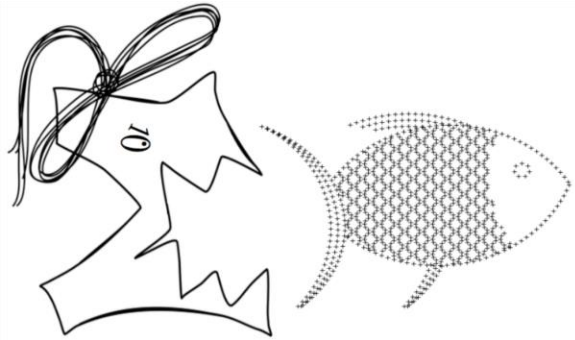
- Do grade 4-5 students demonstrate an understanding of State Diagrams by being able to translate between different representations?
- Do grade 4-5 students demonstrate equal facility for translating between different representations of state diagrams?
- Can grade 4-5 students understand the role of 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?
- Are grade 4-5 students engaged by state diagrams and their applications to adventure games?
- Do grade 4-5 students understand abstract and concrete states equally well? Will students presented with concrete states generalize to abstract states without prompting?

Related work (CS)

- [Anderson-Inman and Horney, 1996]
  - Concept maps can allow mental mapping of written stories and allow for an easier method for students to record their ideas before starting the writing process
- [Ben-Ari, 1998]
  - Says performance is no indication of understanding.
- [Brown., 2016]
  - MacVenture, iPad application to create adventure game without any lines of code.
- [Vico et al., 2019]
  - It is possible for students to have a basic understanding of coding in the elementary schools.
- [Bers, 2019].
  - Coding can change the way we think and experience the world around us.
- [Suters and Suters, 2020]
  - Coding is helpful to teach maths at elementary level.
- [Goldenberg and Carter, 2021].
  - Computer science is as important as English and should be taught in the elementary schools.
- [Lukkarinen et al., 2021].
  - It is a literature review paper which says EDP is the way of teaching beginners with interactive diagrams, it focuses on behavioural characteristics and lets programmers to consider the consequences of user actions and ways to handle them.

Related work (Visual Learning)

- [Chang., 2012]
  - when child partners with an adult in learning through drawing, there is a healthy language growth enables kids to listen, think and then speak.
- [Schmeck et al., 2014]
  - says students who learned through drawing scores higher than students learned through text-based comprehension.
- [Cheng and Beal., 2020]
  - students were willing to learn when pictures are provided than to draw by themselves.
- [Park et al., 2020]
  - says that learning through drawing helps in taking different prespectives and expose to other domains like maths and literature when working in groups.
- [Ainsworth and Scheiter., 2021]
  - A study listing the advantages of drawing such as increased attention, increased focus during group collaboration etc.



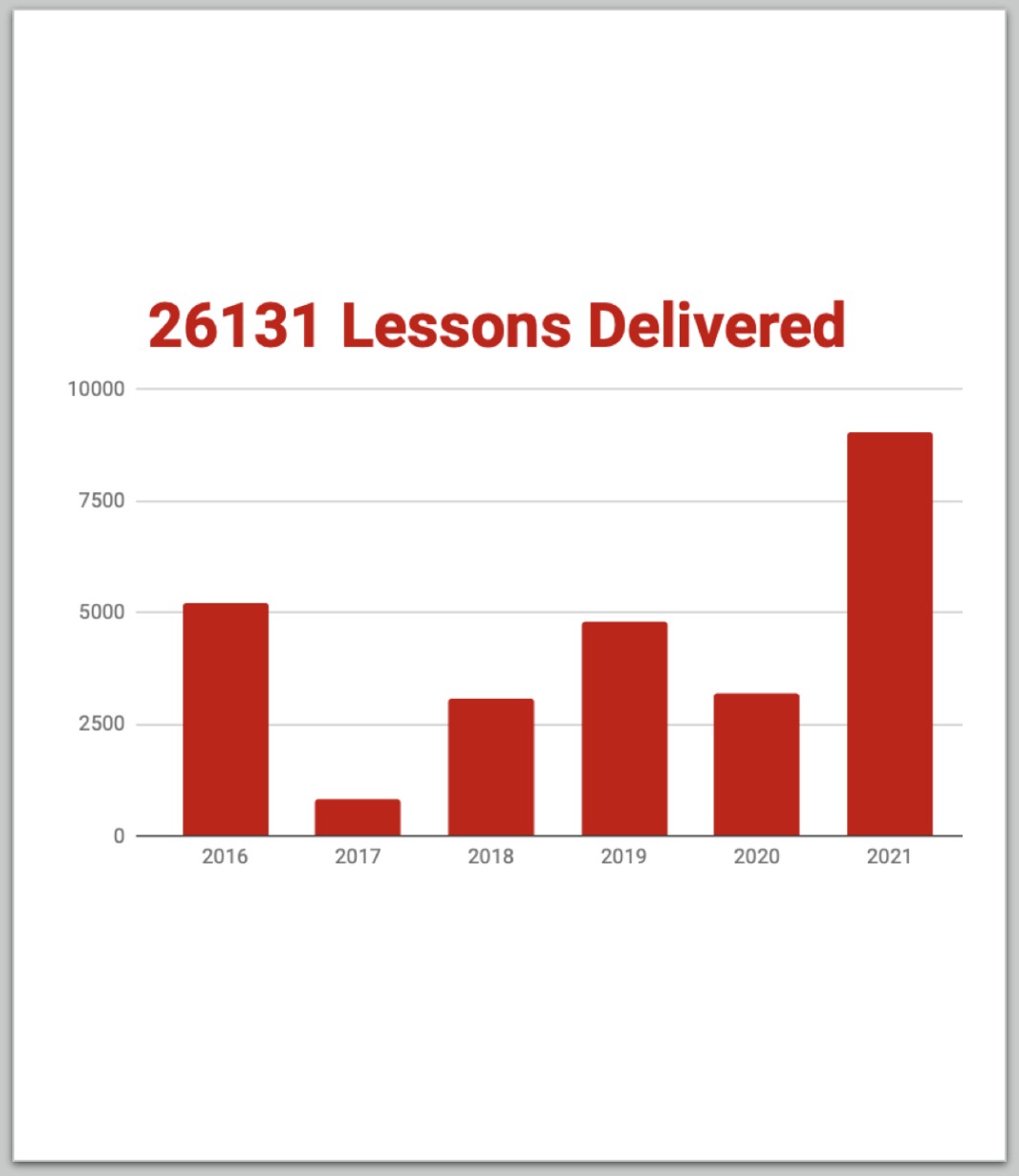
McMaster Start Coding

Grades 4-8

Undergrad mentors

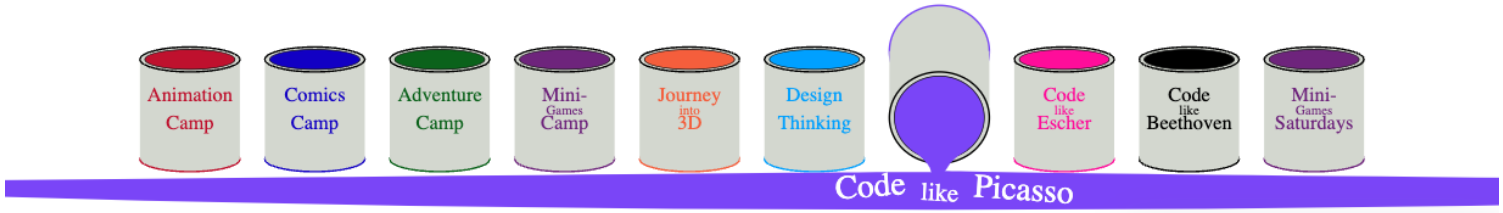
High school mentors

1000 classes



Depth = Camps

Nine camps make links across every subject in K-8 curriculum.



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?"

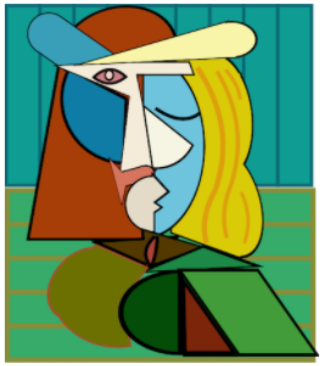
Learning objectives

- 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:

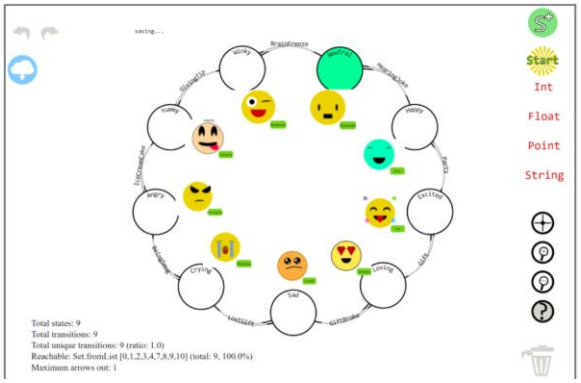


Camp Outputs

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

https://youtu.be/7cU1c42tHqk

- Social-Emotional Learning
  - Emoji Game

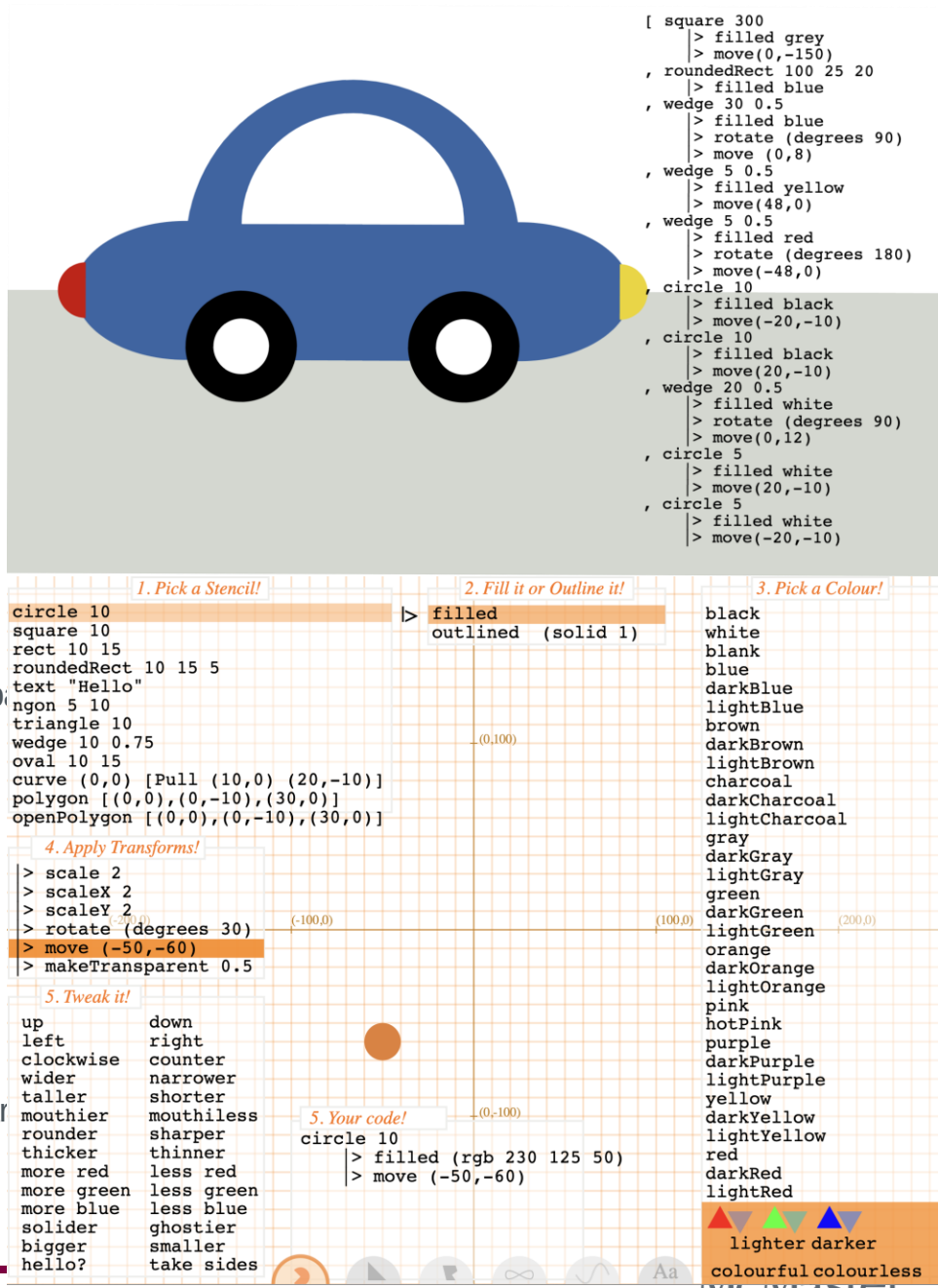


Advantages

- **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 p
  - Functional Programming matches Algebra
  - Scratch, Python matches Recipes

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



Advantages

```
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)
  ]
```

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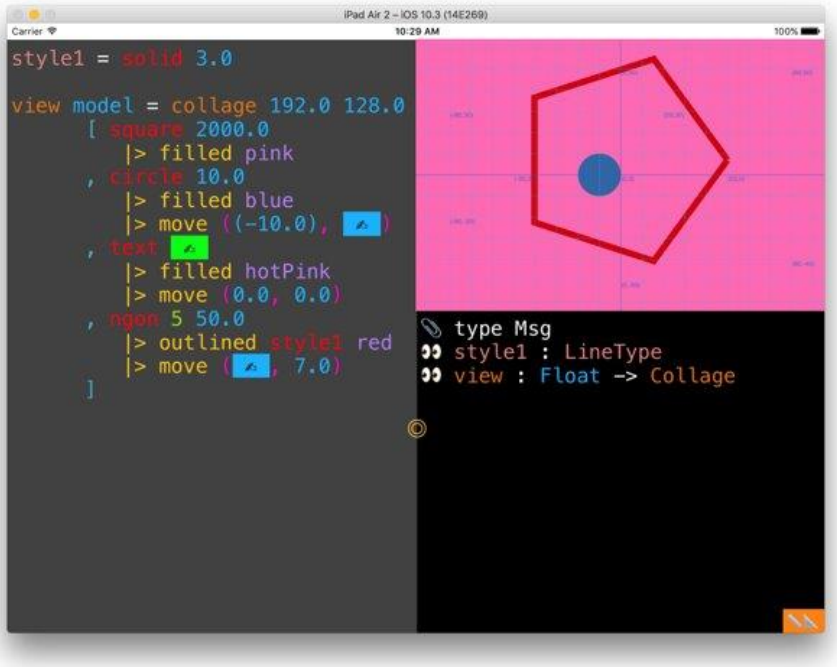
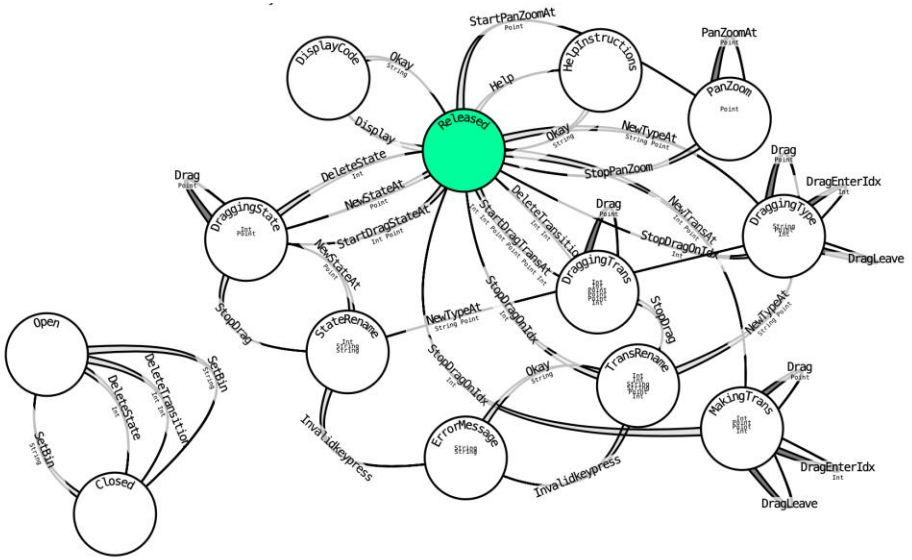
Advantages





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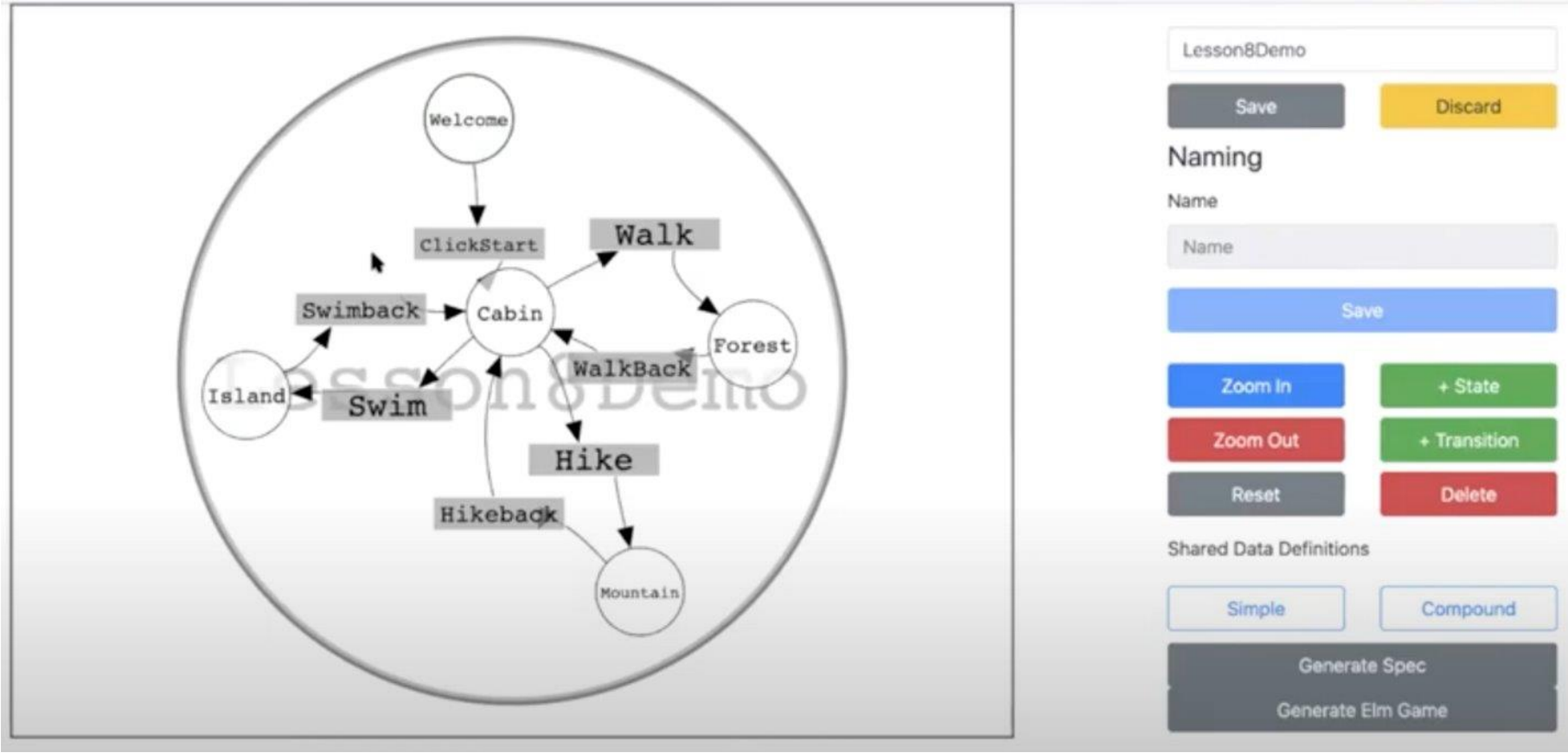
    - **Generate code automatically to accelerate learning**
  - **Create interactive games from scratch in week 1**

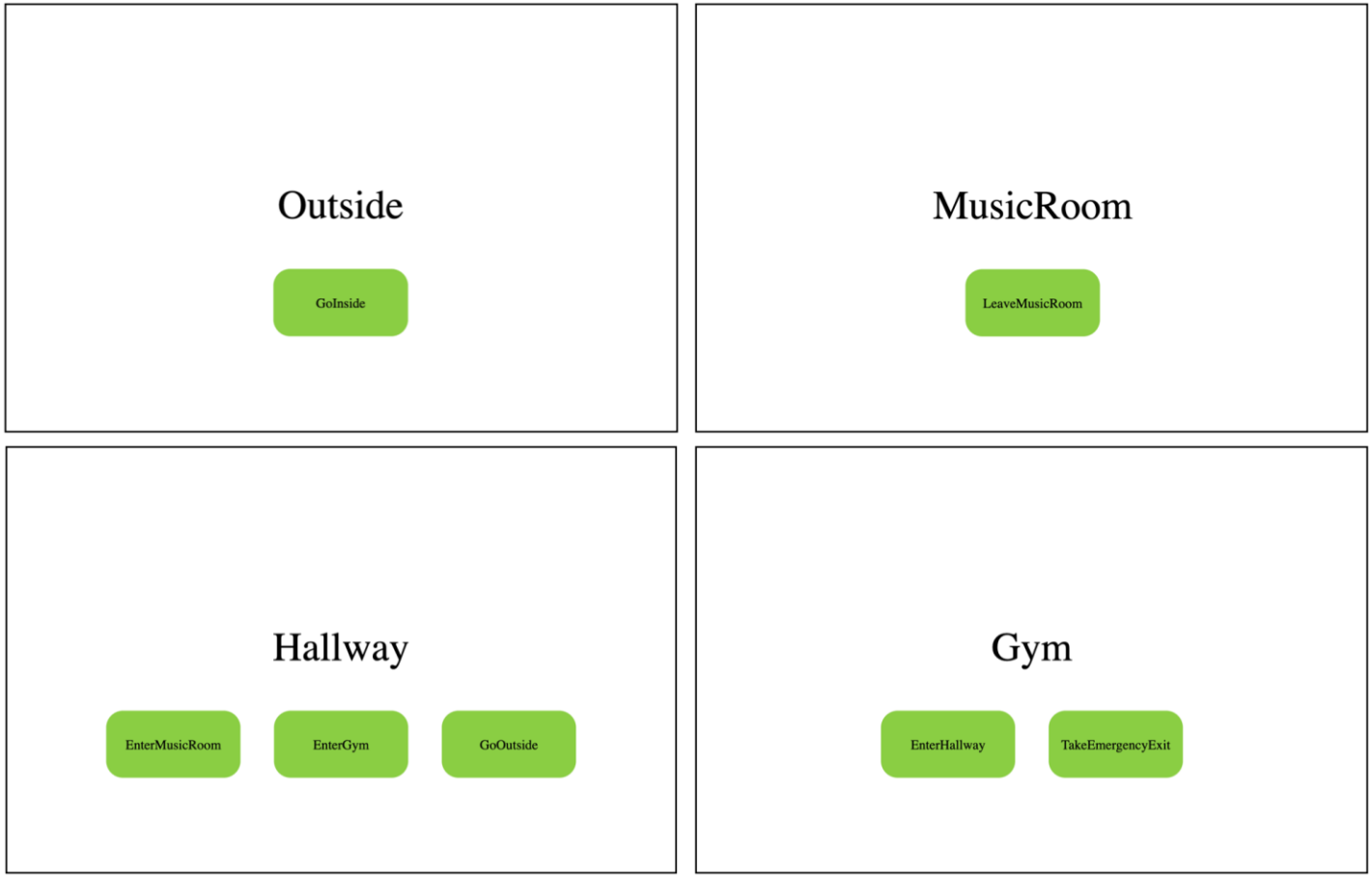
PAL Draw



- Written for Petri App Land, a MDD experiement for distributed computation.
- State Diagrams were contained in Places.
- Super clunky Bootstrap interface, SD component written in 2 days.

But kids loved it!

Because it generated the code for them.



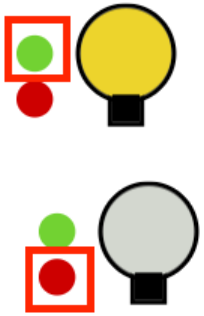
Elm Architecture

```
type alias Model = { time : Float, state : State }
```

Model

```
init : Model
init = { time =0
       , state = ON
       }

type State = ON | OFF
type Msg = Tick Float GetKeyState | TurnOn | TurnOff
```

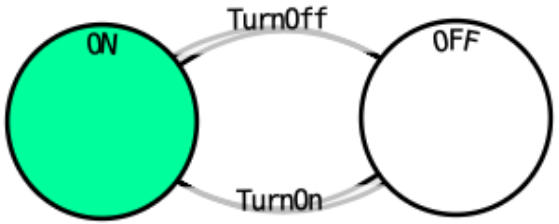


```
myShapes model = [ group [ circle 5 |> filled (if model.state == ON then yellow
                                               else gray)
                         , square 3 |> filled black |> move (0,-6)
                         ] |> addOutline (solid 1) black
                 , circle 2 |> filled green |> move (-10,0) |> notifyTap TurnOn
                 , circle 2 |> filled red |> move (-10,-5) |> notifyTap TurnOff
                 ]
```

View

```
update msg model =
    case msg of
        Tick t _ -> { model | time = t }
        TurnOn   -> { model |  state = ON }
        TurnOff  -> { model | state = OFF }
```

Update

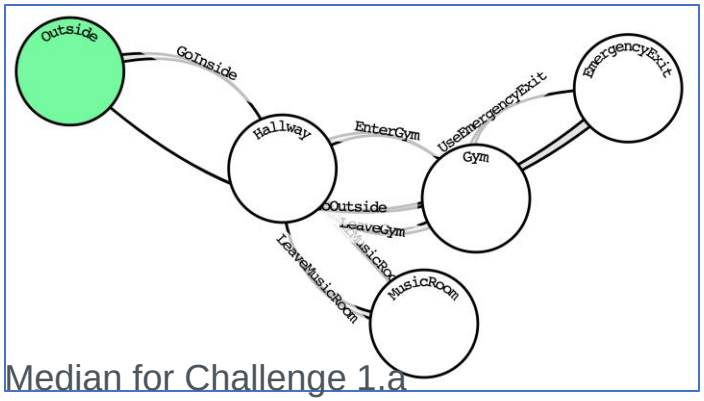


Lesson and Challenge Design

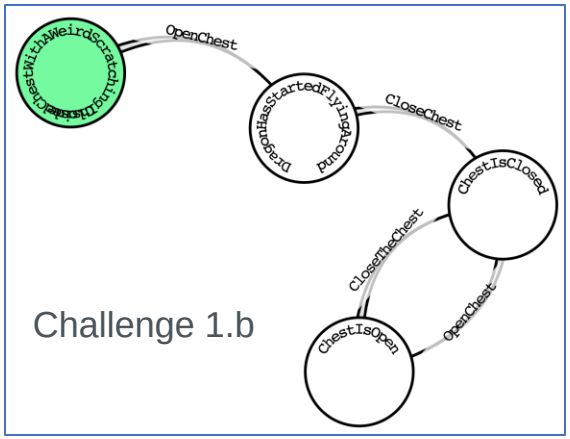
Activity				Time taken	
Moo Quack game shown as state diagrams and students type noises in the chat				30 minutes	Day 1
States of matter and Canadian provinces state diagrams are explained				30 minutes	
Make a SD together with the class and generate code. Ask them for ideas of places, come-up with transitions that make sense and have some variety				30 minutes	
Work together in groups of 3 or 4 students to create their own map for an adventure game, generate the code and verify that the buttons work, start making shapes.				1 hour	
Split up into 4 Zoom rooms and get instructions about challenge. Each challenge has two different games, School Navigation and Dragon Release Video game. Mentors: split them up into 1 and 2 evenly and assign one school navigation to Team 1 and Dragon game to Team 2. Challenge should be completed individually.				1 hour	Day 2
Challenge 1: Draw a state diagram from a paragraph description	Challenge 2: Draw a state diagram from a list of bullet points	Challenge 3: Describe the given state diagram into an English paragraph	Challenge 4: Draw the state diagram of the given game.		

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

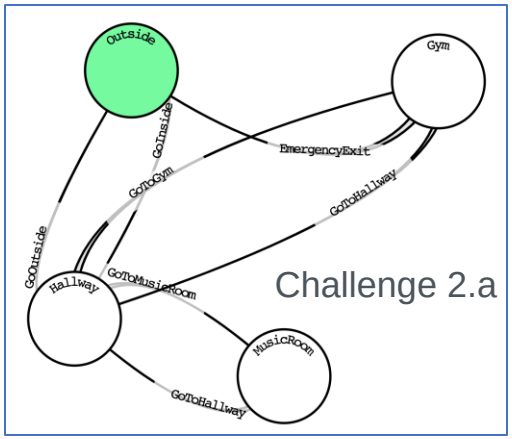
Yes, when students were given different representations and asked to convert them, they were able to do so



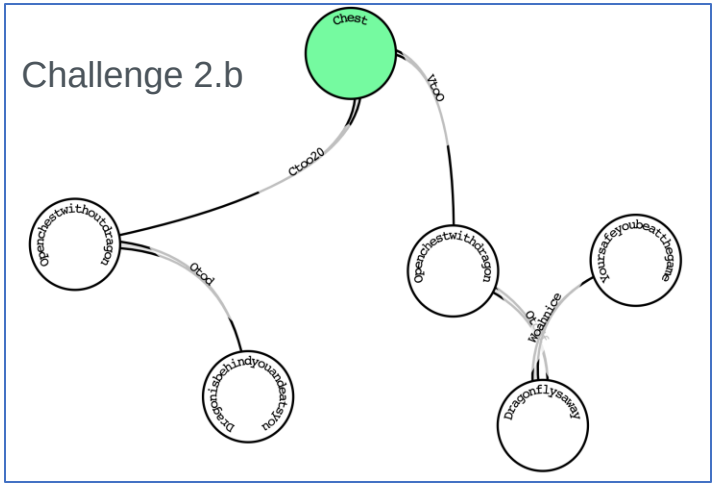
Median for Challenge 1.a



Challenge 1.b

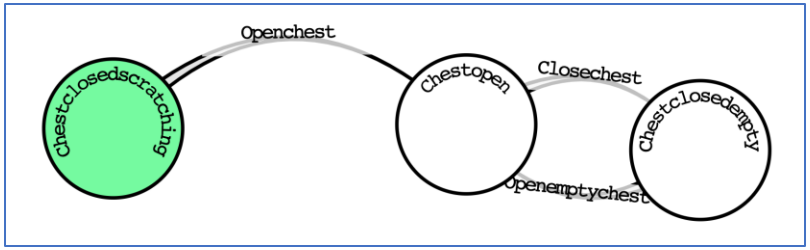


Challenge 2.a



Challenge 2.b

Challenge 4.b

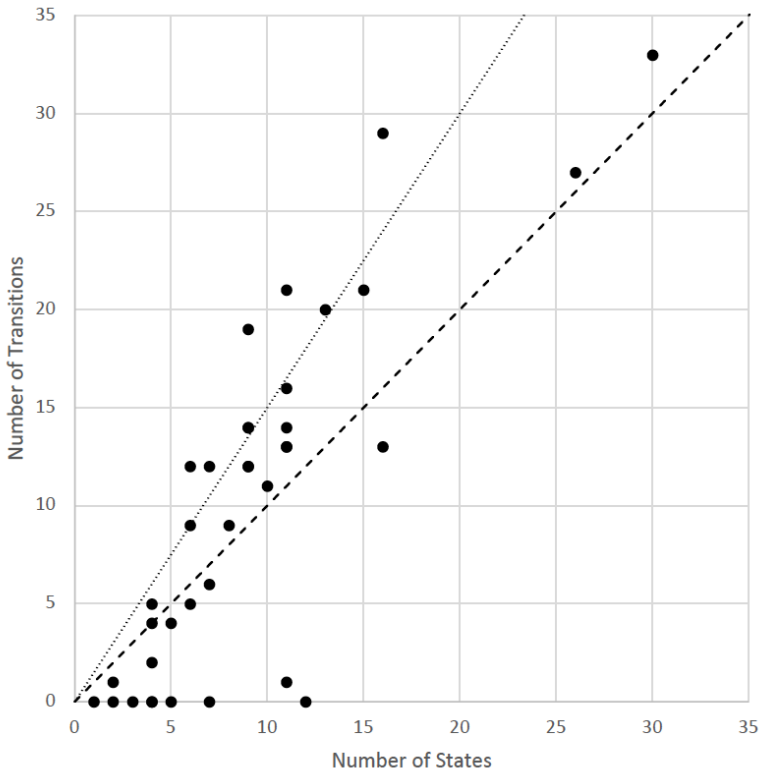


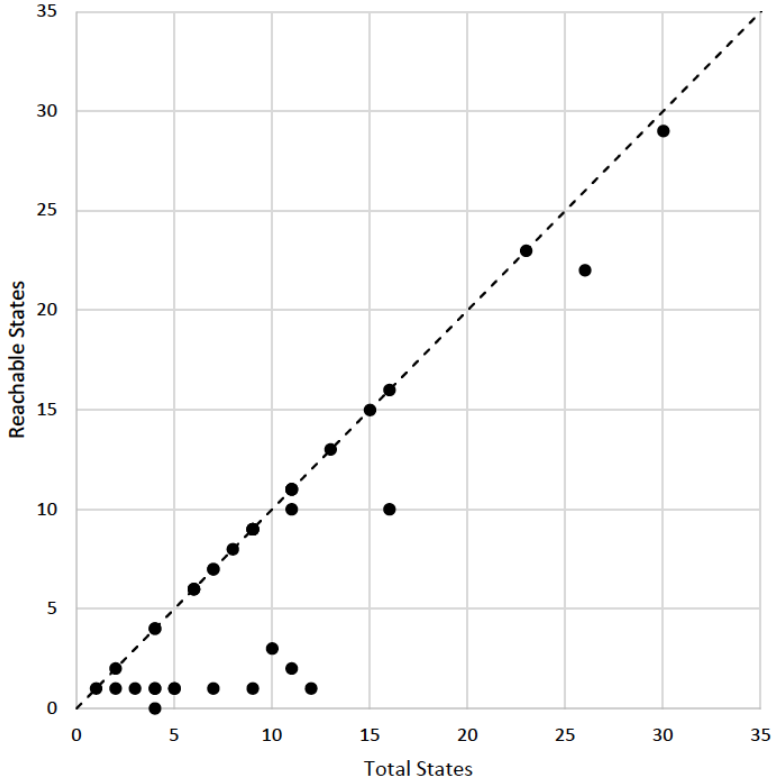
RQ2: Do grade 4-5 students demonstrate equal facility for translating between different representations of state diagrams?

No. When a state diagram is given and students are asked to write a description about it, students were confused how much to write, especially in the case of a cycle in the state diagram. Students also found it easier to interpret point-form specifications rather than paragraphs, and found the conversion of a working app into a State Diagram easiest of all

Our median response for Challenge 3a was: *You start outside the school. If you go inside through the door, you'll be at the hallway. Here, you can access all the different rooms or exit the hallway to go back outside. The music room is the room labeled ``music,'' and you can enter and exit it through the door. From the hallway, you can also enter the gym room, and exit it back through the door. If you are in the gym and there is an emergency, you can take the emergency exit instead of running back to the hallway and exiting that way. There is no emergency exit in the music room, since there is nowhere to go after you leave.*

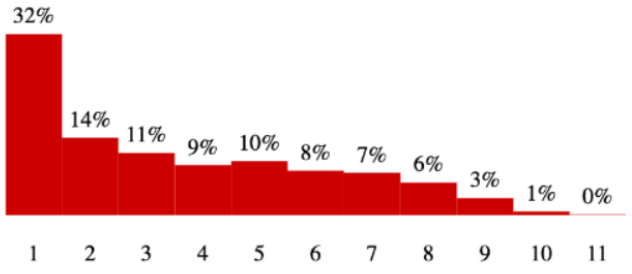
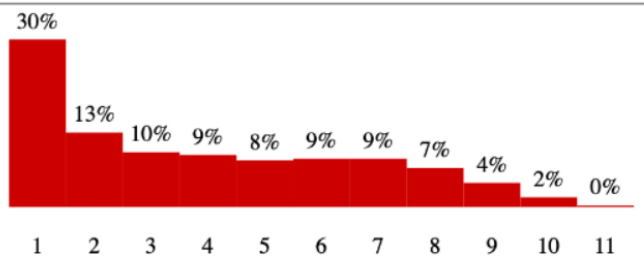
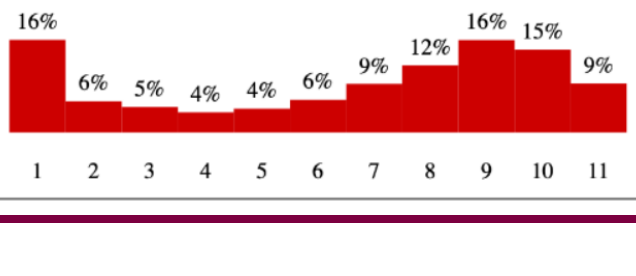
RQ3: Can grade 4-5 students understand the role of reachability?





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.

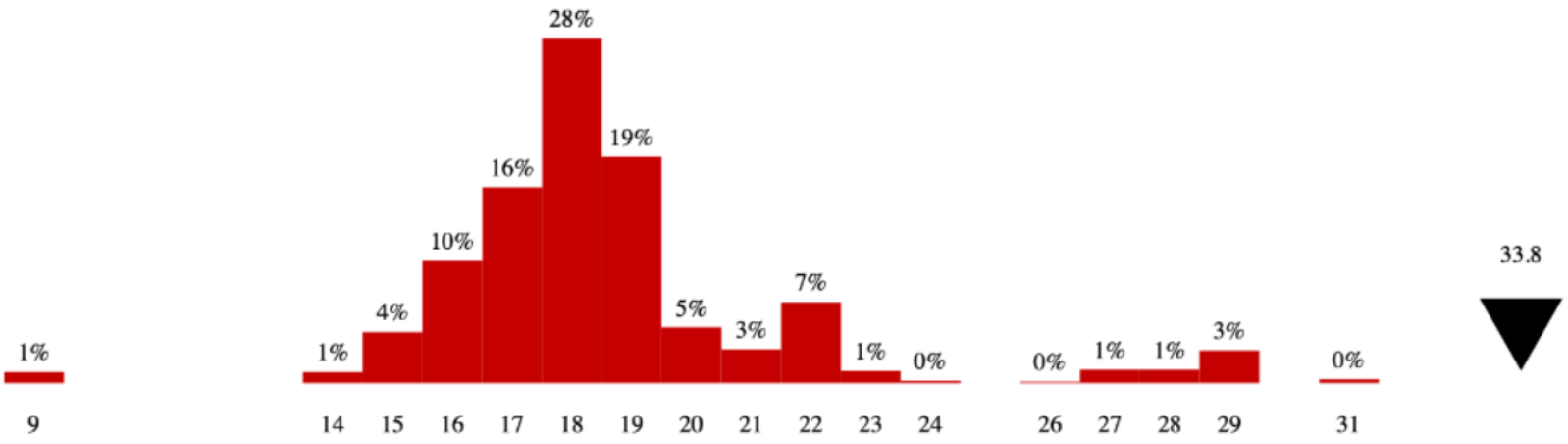
States	Transitions	Probability Distribution Function	Observed
11	13		10,11
11	14		11
11	21		11

Anderson-Darling Test

$$A^2 = n \int_{-\infty}^{\infty} \frac{(F_n(x) - F(x))^2}{F(x)\,(1 - F(x))}\, dF(x)$$

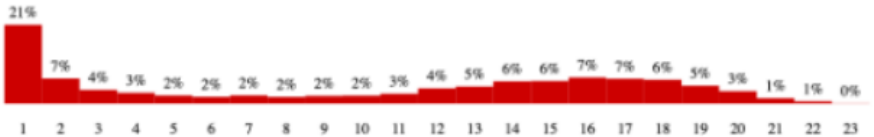
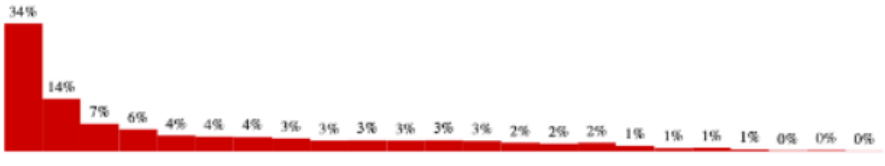
- We asked: Can grade 4-5 students understand the role of reachability? Would randomly generated diagrams be as reachable?
- Anderson-Darling: Is data X from distribution F?
  - Simulated randomly generated diagrams.
  - Compute A^2

***p* < 0.001** (only S=11)



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

  - Yes!
  - Spent more time on the diagram than on 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?