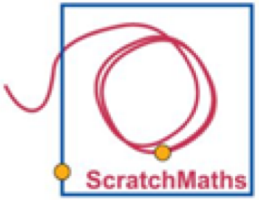

Integrating Coding and Maths in K-12: Research and Practice

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newcastle.edu.au/cs4s

Talk Overview

- *Coding*, *Computational Thinking* (*CT*) and Learning Maths

- 3 Projects from UON that involved *Coding*, *CT* & Learning Maths
  - A Scoping Review of *Computational Thinking* in K-12 Maths Education
  - *ScratchMaths* Pilot
  - *CS4HS Networks* workshop

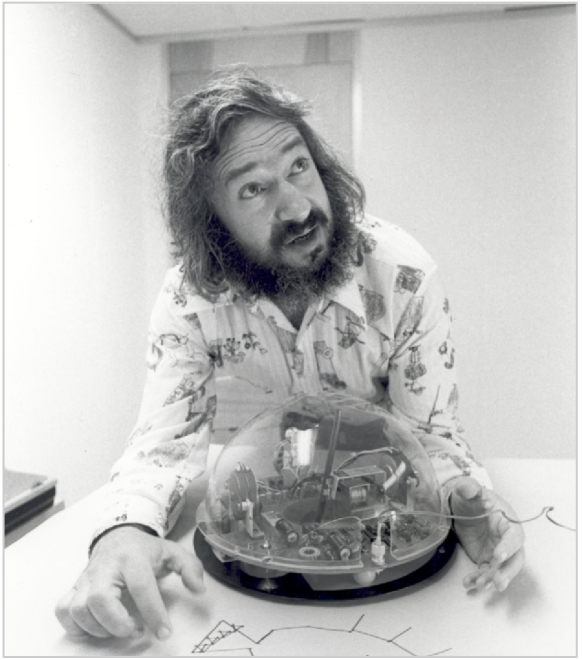
- Our Experiences and Lessons Learned

*"Here's the big idea. **Maths is difficult** in part because of the **language** in which it is expressed. Can we find a different language – and set of ideas and approaches - that is more open, more accessible and more learnable. And can we find it without sacrificing what makes mathematics work? Our tentative answer is 'yes' – **the language of programming** might be just such a language"*

What's the problem?

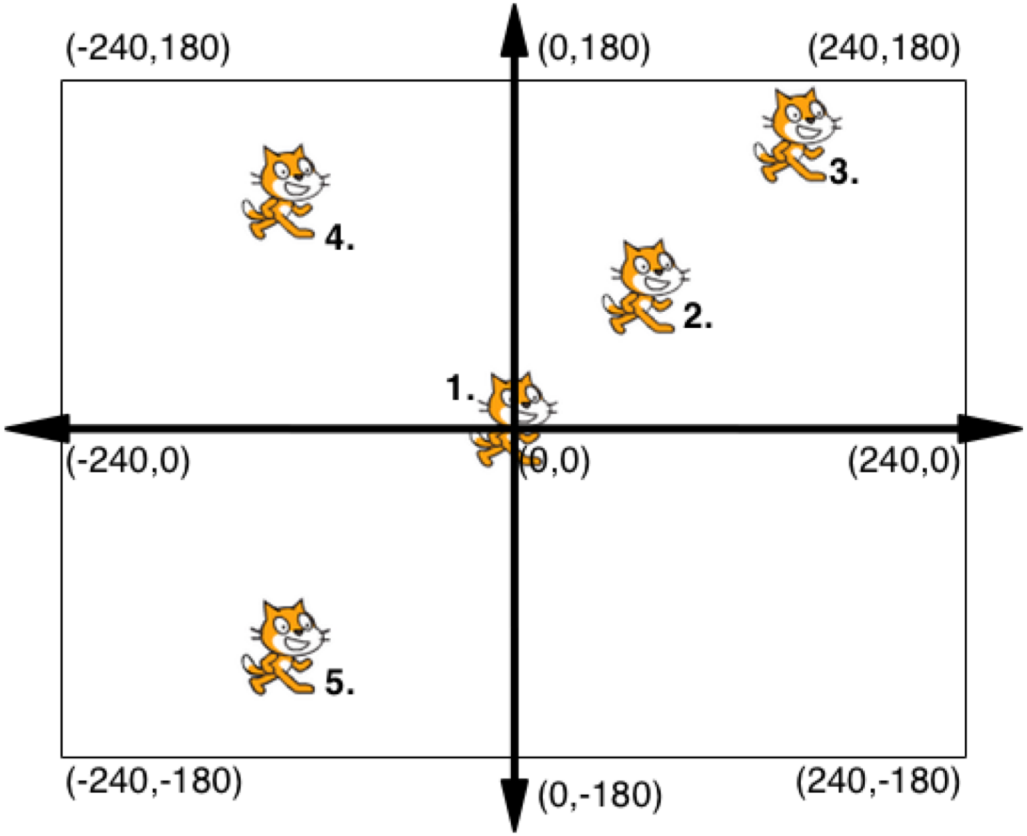
UCL ScratchMaths Homepage: http://www.ucl.ac.uk/ioe/research/projects/scratchmaths

Coding, *CT* and Learning Maths



- Examples of combining Maths and *Coding*:
  - *Logo*
  - *Boxer*
  - *Bootstrap*

- Researchers have found that *Coding* can help concretise abstract Maths concepts that learners struggle with (Kafai 1998, Papert 1980)



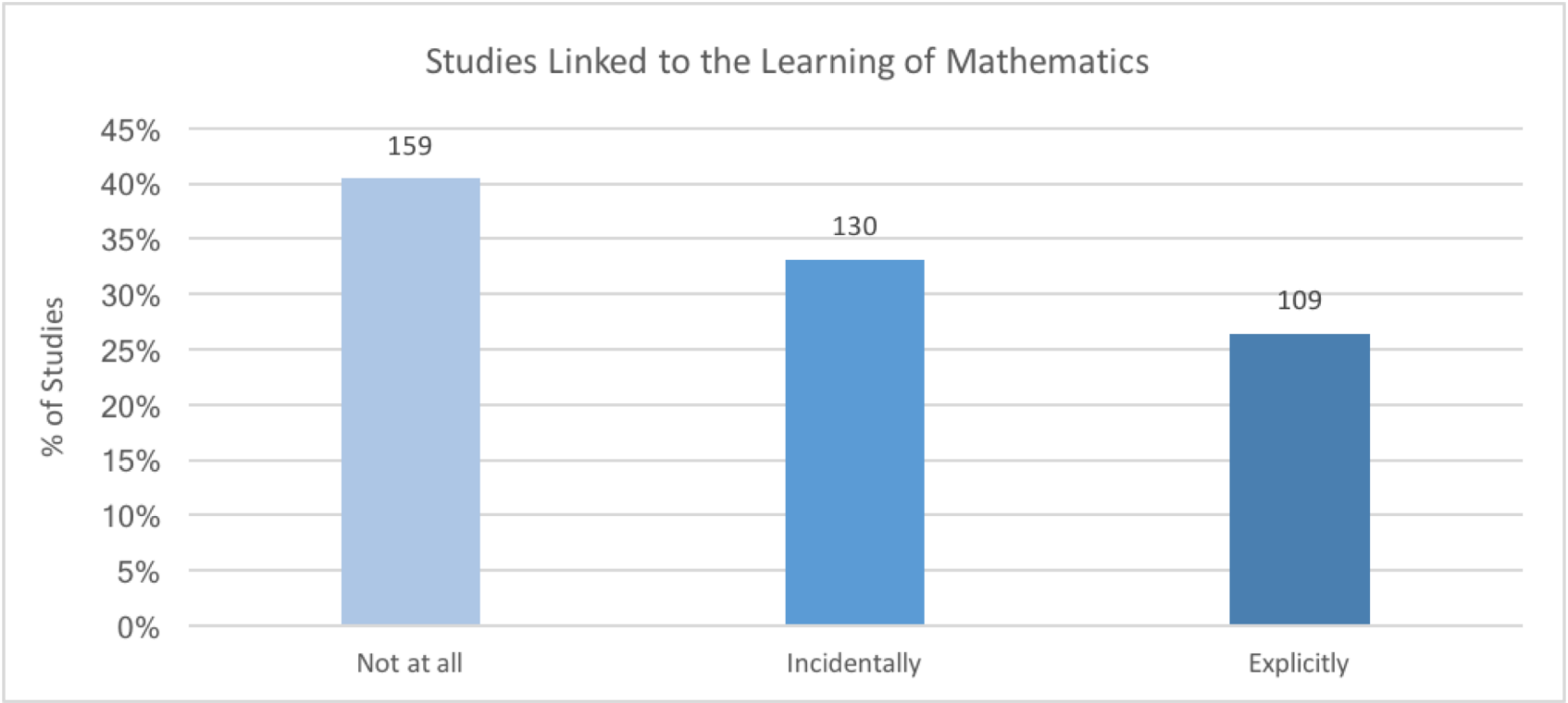
1. go to x: 0 y: 0
2. go to x: 70 y: 70
3. go to x: 150 y: 150
4. go to x: -120 y: 120
5. go to x: -120 y: -120

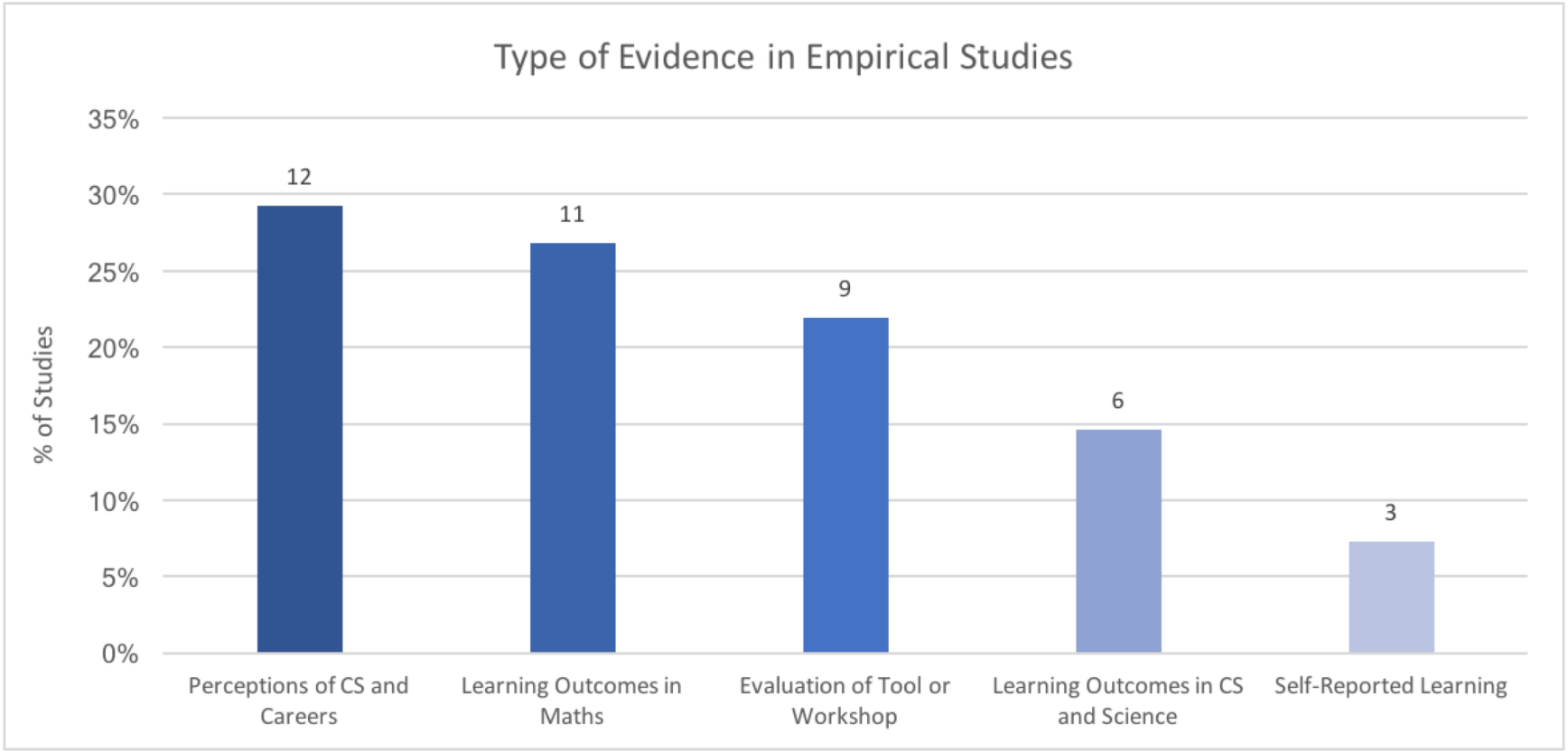
Projects: Scoping Review

- We conducted a scoping review of literature on *Computational Thinking* (*CT*) in K-12 Education from 2006 to 2016
  - 393 papers in total, after removing duplications and irrelevant studies

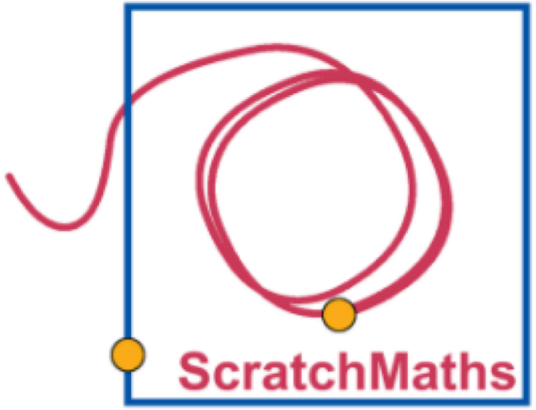
- Classified how *CT* and learning of Maths were linked in the studies:
  - *Not at all*
  - *Incidentally*
  - *Explicitly*

- Also classified the type of study and the outcomes measured

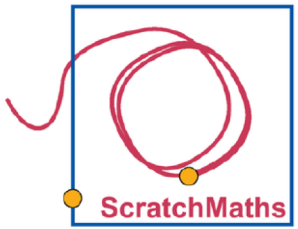

Studies Linked to the Learning of Mathematics
% of Studies
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
159
130
109
Not at all
Incidentally
Explicitly

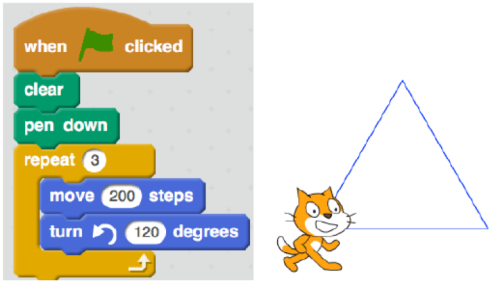

Type of Evidence in Empirical Studies
% of Studies
35%
30%
25%
20%
15%
10%
5%
0%
12
11
9
6
3
Perceptions of CS and Careers
Learning Outcomes in Maths
Evaluation of Tool or Workshop
Learning Outcomes in CS and Science
Self-Reported Learning

ScratchMaths



What is *ScratchMaths*?





- The development of materials that teach *Coding* and Maths at Year 5/6
- An evaluation (*Randomised Control Trial*) of the curriculum materials and their effects on students' Maths and *Coding* ability in 100+ English schools

ScratchMaths in Australia

- Dr Elena Prieto (University Of Newcastle) and Prof Kathryn Holmes (Western Sydney University) want to bring *ScratchMaths* to Australia.

- But first, they need to know how the *ScratchMaths* materials can be adapted for the Australian context

- Conducting a pilot research project involving Professional Development (PD), surveys and interviews to find out

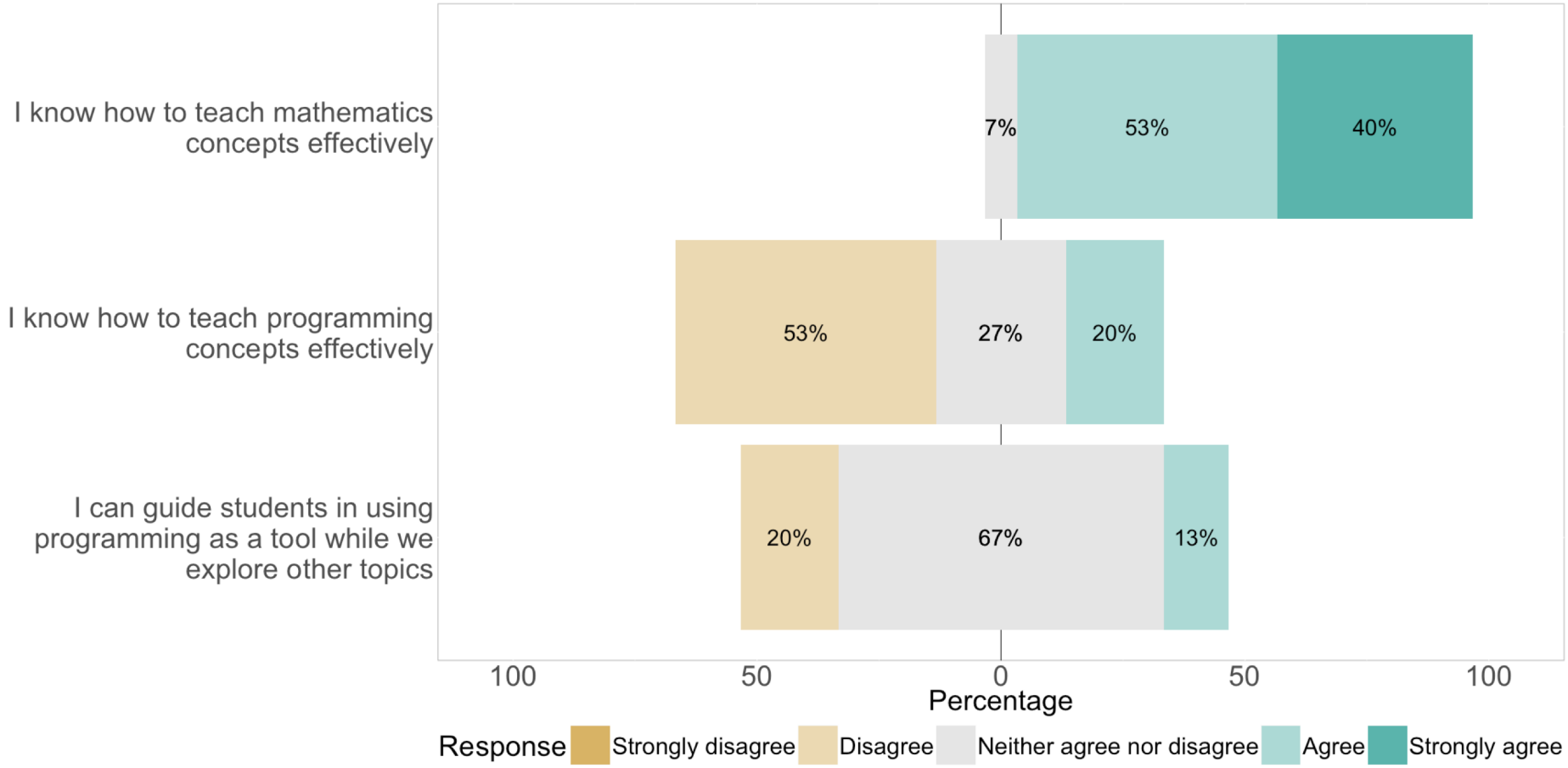
ScratchMaths in Australia

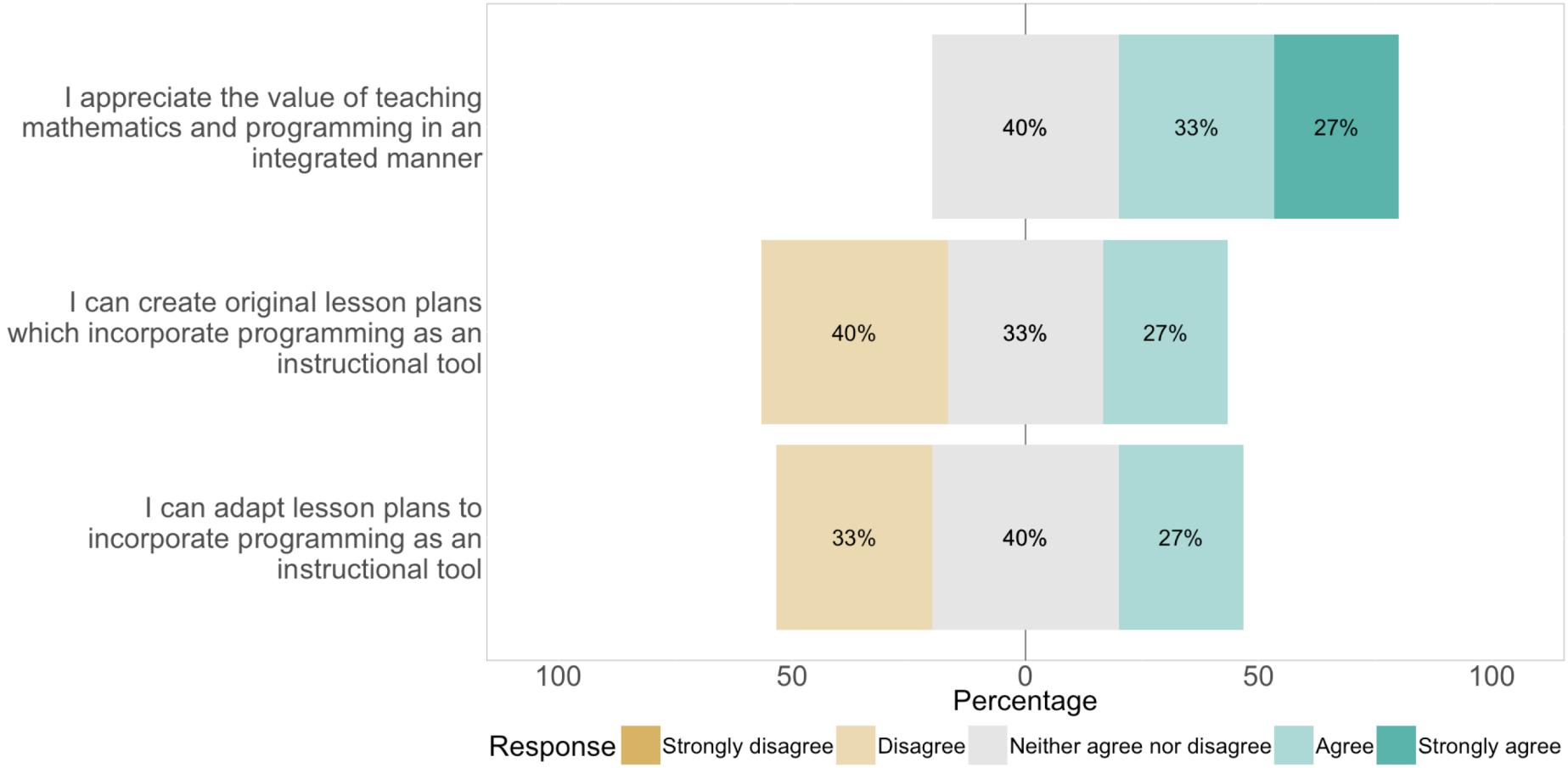
- We ran two day PD workshops for 13 teachers at:
  - University of Newcastle
  - Western Sydney University

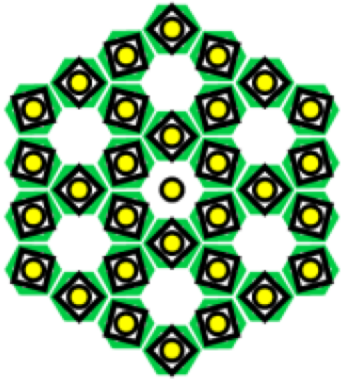
- Day 1: *Computational Thinking*, Scratch and Teacher Accounts

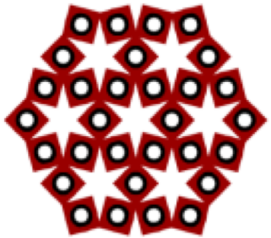
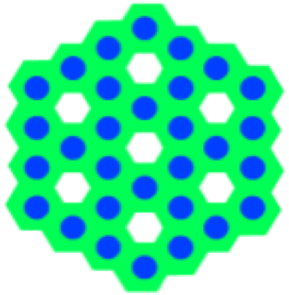
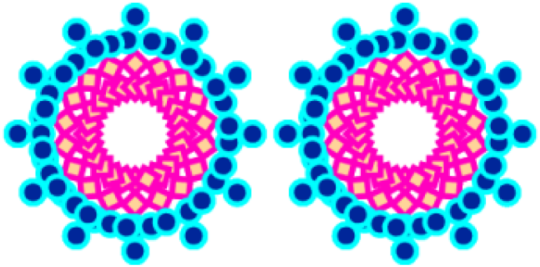
- Day 2: *ScratchMaths* Module 1: Tiling Patterns (Geometry)

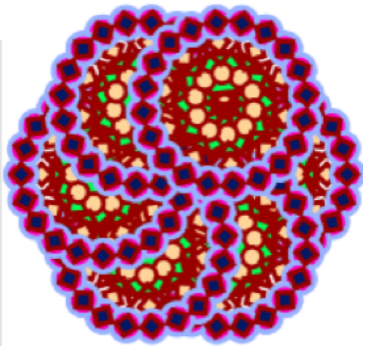
- Post-workshop: implementation in Stage 3 classes


I know how to teach mathematics concepts effectively
I know how to teach programming concepts effectively
I can guide students in using programming as a tool while we explore other topics
7%
53%
40%
53%
27%
20%
20%
67%
13%
100
50
0
50
100
Percentage
Response
Strongly disagree
Disagree
Neither agree nor disagree
Agree
Strongly agree


I appreciate the value of teaching mathematics and programming in an integrated manner
I can create original lesson plans which incorporate programming as an instructional tool
I can adapt lesson plans to incorporate programming as an instructional tool
40%
33%
27%
40%
33%
27%
33%
40%
27%
100
50
0
50
100
Percentage
Response
Strongly disagree
Disagree
Neither agree nor disagree
Agree
Strongly agree





*“I absolutely loved ScratchMaths, i****t was so fun learning all about coding and was something i looked forward to every Monday.*** *I enjoy having to find the problem when it goes wrong and then making the code much better. I find it really cool that you can program a computer to do something like turning a certain amount of degrees or moving a certain amount of steps.* ***ScratchMaths was difficult at first but once I learnt the basics all i wanted to do is learn more. Computer Science is great fun and is perhaps my favourite thing at school each week. I learnt that if the repeat block is 6 then the degrees will have to be 60 because 6*60 is 360 and it has to equal 360 degrees if you want a full pattern.*** *I liked it alot because its* ***a whole new aspect of learning that none of us had tried before.****”*

From a Stage 3 student in one of the *ScratchMaths* Teacher’s classes

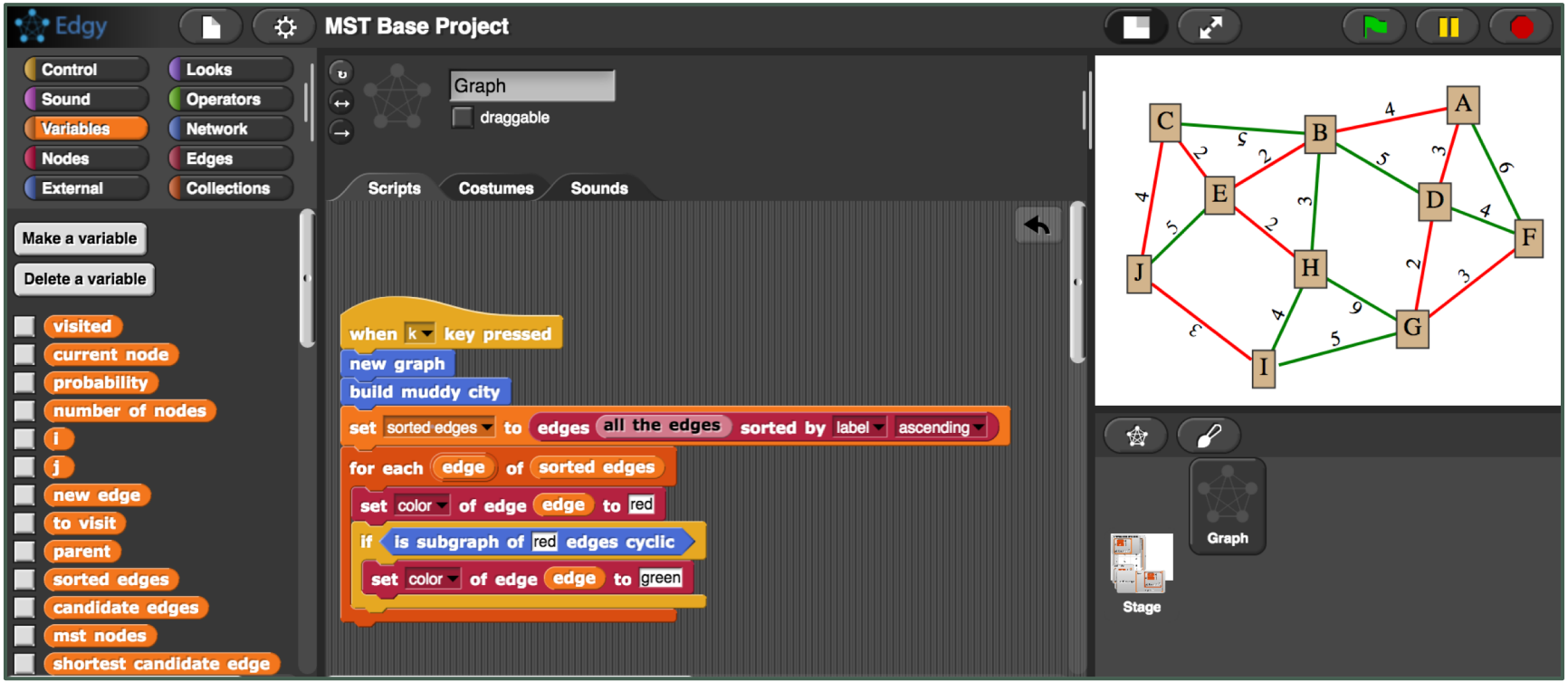
Google CS[4]HS

CS4HS Networks

CS4HS Networks

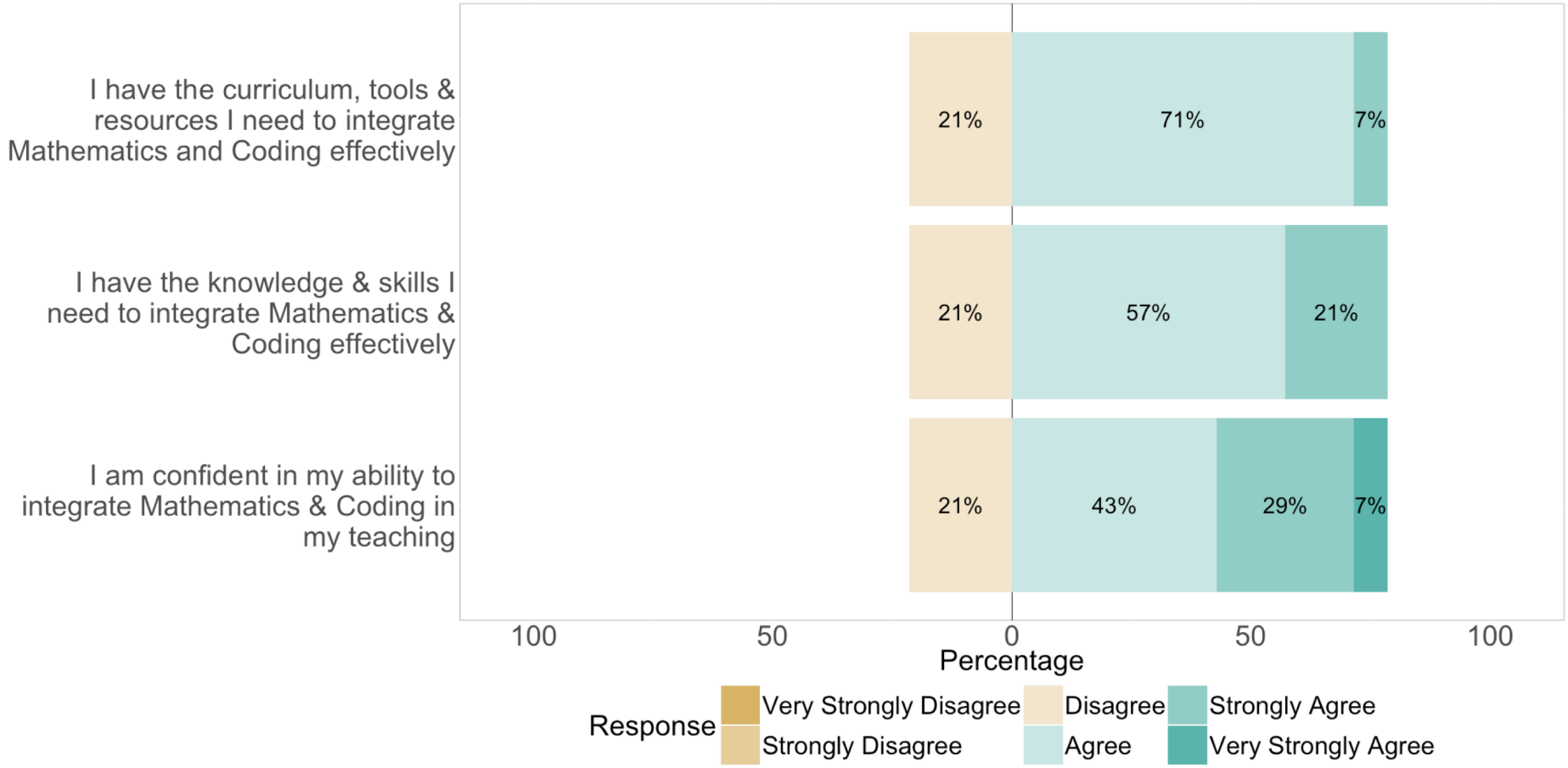
- In NSW, *Networks* (Graph Theory) will be added to the Mathematics Standard syllabus at Stage 6 from 2018

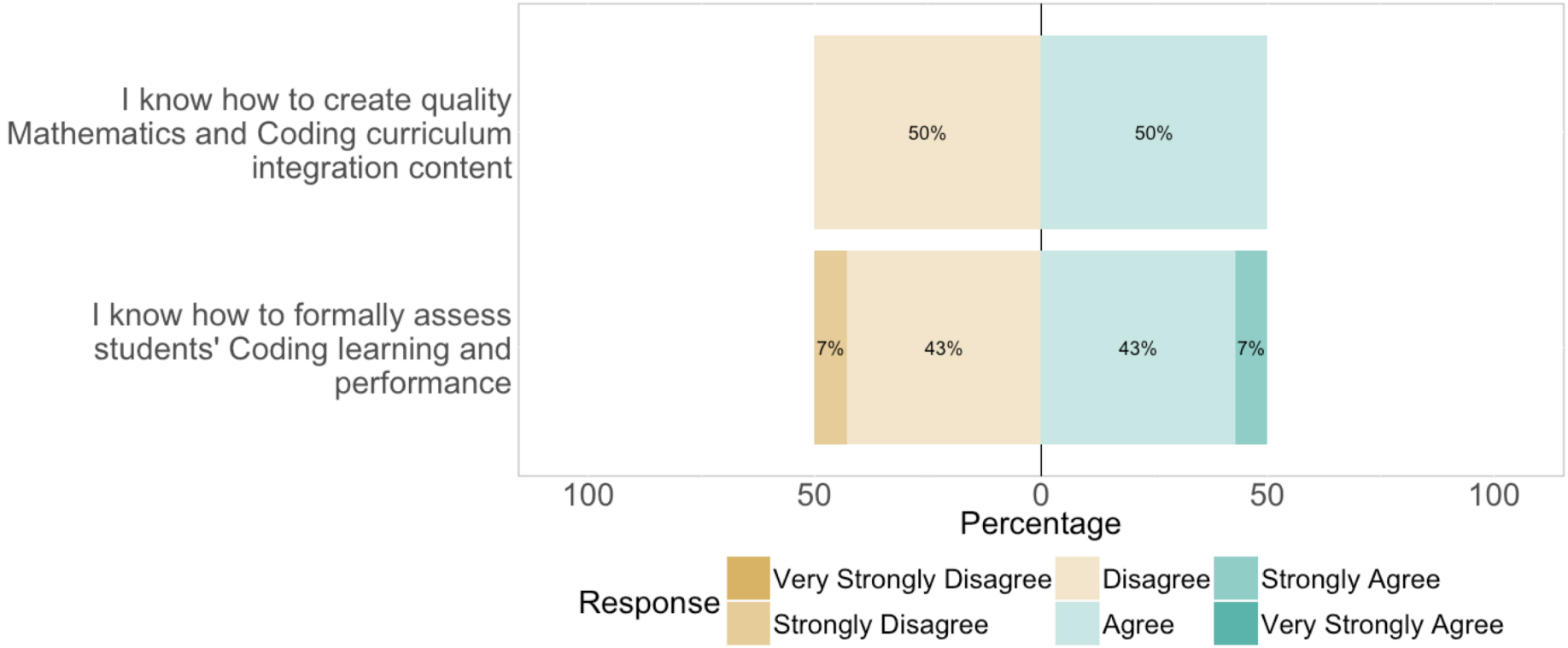
- We ran a CS4HS workshop that combined the teaching of *Networks* and *Coding* with:
  - An *unplugged* approach, using materials adapted from *CSUnplugged's Muddy City* resource
  - And a "*plugged*" approach, using the *Edgy* program (a modification of *Snap! Build Your Own Blocks*)


Edgy
MST Base Project
Control
Looks
Sound
Operators
Variables
Network
Nodes
Edges
External
Collections
Make a variable
Delete a variable
visited
current node
probability
number of nodes
i
j
new edge
to visit
parent
sorted edges
candidate edges
mst nodes
shortest candidate edge
Graph
draggable
Scripts
Costumes
Sounds
when k key pressed
new graph
build muddy city
set sorted edges to edges all the edges sorted by label ascending
for each edge of sorted edges
set color of edge edge to red
if is subgraph of red edges cyclic
set color of edge edge to green
A
B
C
D
E
F
G
H
I
J
Graph
Stage

CS4HS Networks

- 15 teachers participated in the 2 day workshop
  - The majority were Maths teachers, the rest taught Science and/or Technologies
- We asked for feedback from teachers at the end of the workshop
- I am interested in developing these materials more
  - The materials are currently available at: cs4s.github.io/math-2017


I have the curriculum, tools & resources I need to integrate Mathematics and Coding effectively
I have the knowledge & skills I need to integrate Mathematics & Coding effectively
I am confident in my ability to integrate Mathematics & Coding in my teaching
21%
71%
7%
21%
57%
21%
21%
43%
29%
7%
100
50
0
50
100
Percentage
Response
Very Strongly Disagree
Strongly Disagree
Disagree
Agree
Strongly Agree
Very Strongly Agree


I know how to create quality Mathematics and Coding curriculum integration content
I know how to formally assess students' Coding learning and performance
50%
50%
7%
43%
43%
7%
100
50
0
50
100
Percentage
Response
Very Strongly Disagree
Strongly Disagree
Disagree
Agree
Strongly Agree
Very Strongly Agree

Our Experiences and Lessons Learned

Our Experiences and Lessons Learned

- We have observed that our challenges running professional development are similar to the ones teachers face in their classes:
  - Preparation time for resources
  - Differentiating for learners with varying CS knowledge
  - Balancing direct instruction with self-directed learning - the *“play paradox”* (Noss & Hoyles, 1996)
  - Sometimes the lab computers or websites we use do not work

Our Experiences and Lessons Learned

- From preliminary analysis and reflection on our experiences:
  - There are many opportunities for integrating *Coding*, *CT* and Maths
  - Teachers see the value of integrating *Coding* into different KLAs
  - Teachers need time and practice to learn *Coding*
  - There is a need for both:
    - Larger-scale studies that evaluate materials/approaches that teach *Coding* and Maths (like *ScratchMaths* in England)
    - Studies that take an in-depth look at how teachers learn *Coding* and how they integrate it across different KLAs (like my planned Ph.D project)

Questions?

Presenter: daniel.hickmott@uon.edu.au

Newcastle CS4S website: newcastle.edu.au/cs4s

Newcastle CS4S resources: cs4s.github.io/