Computing education in non-formal settings

Research to practice

Rebecca Franks and Dr Tracy Gardner
This talk

- 321 Make - A research-informed framework for non-formal computing education
- Our non-formal computing literature review
- What next?
Who are we?

Rebecca Franks
⭐ Secondary Computing teacher (and director) for over 15 years
⭐ Pupil premium lead
⭐ Co-chair of CAS Include
⭐ Joined the foundation in 2019
⭐ Developed resources for the Teach Computing Curriculum and Isaac CS
⭐ Regular Hello World contributor and Raspberry Pi blog author
⭐ Moved to the Informal Learning Team in 2021
⭐ @FranksberryPi

Dr Tracy Gardner
⭐ Entered computing via an outreach program (first in family to get any qualifications)
⭐ Computer Science PhD
⭐ Career in industry as a software architect (IBM)
⭐ Co-author of micro:bit in Wonderland
⭐ Taught primary computing, ran a Code Club and CoderDojo, hack events
⭐ Started writing Code Club projects in 2015
⭐ picozero library co-developer
Where we fit in the Raspberry Pi Foundation

Raspberry Pi Foundation

Research team

Informal Learning Team

Raspberry Pi Computing Education Research Centre

CoderDojo

University of Cambridge
A definition of non-formal education

“institutionalised, intentional and planned by an education provider. The defining characteristic of non-formal education is that it is an addition, alternative and/or complement to formal education within the process of life-long learning of individuals”

Our programmes are global

- **Code club** A global network of free coding clubs for 9–13 year olds - 160 countries

- **CoderDojo** The community of free, local programming clubs for young people age 7-17 - Over 100 countries

- **Coolest Projects** - The world’s leading technology showcase for young people - Anywhere in the world.
321 Make!

Our framework

rpf.io/321-make

Raspberry Pi Foundation

Supporting creators age 7-18 to make things that matter to them!
What problem are we trying to solve?

“Beware of the Turing tar-pit in which everything is possible but nothing of interest is easy.” Alan Perlis
What problem are we trying to solve?

“What beware of the Turing tar-pit in which everything is possible but nothing of interest is easy.” Alan Perlis

I want to make something!

Beginner friendly libraries

Design skills

Faded scaffolding

Things that matter to young people

CoderDojo

Coolest projects
Research (industry, community) to practice

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Supporting creators to make things that matter to them!

What creators are making
- Scratch community
- Coolest Projects
- Our clubs

Creator interests
- Popular hobbies
- Medium-term trends
- Interests and causes

Existing project types
- Step by step
- Open guided, e.g. chat bot
- Missions, e.g. Aardman, Astro Pi

CS for what?
- Creativity
- Social action
- Careers, Education
- Making the future
- Community

Research
- Culturally responsive
- Constructionism
- Scaffolding
- Universal Design for Learning
- Cognitive load

RP Foundation Goals
- Coolest Projects
- Creative expression
- Diversity & Inclusion
- Accreditation
- Digital Making Framework

Experience
- Creating content
- Running clubs
- Learner stories
- Feedback

Data
- Popular projects
- Concepts used in beginner projects

CS for what?
Creativity
Social action
Careers, Education
Making the future
Community
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**Discover** introduces creators to new technologies so they can find out if they are interested and ready for more.

3 Explore projects introduce them to new skills.

2 Design projects invite them to practise their new skills and bring in their own interests.

1 Invent project asks them to use the skills they’ve practised to meet a project brief.

**Make** is where creators use their independence to create something totally unique. This could then be entered into Coolest Projects.
321 Make! (A Scratch example)

Explore
- Learn new skills
- Some personalisation

Design
- Practise skills
- Make design choices

Invent
- Combine skills
- Design for your audience/passion

rpf.io/scratch-intro
My personal 321 Make! journey - Unity

- No prior exposure to:
  - C#
  - Unity
  - Creating 3D worlds
- Relatable to my own experiences (particles, collecting, non-player characters)
- By the end, I knew where to look to build the thing that mattered to me!

rpf.io/scramble-trail
Raspberry Pi Pico Path overview

- LED firefly
- Party popper
- Beating heart
- Mood indicator
- Sound machine
- Sensory gadget

OR

ANY

picozero
Learning graph: Introduction to the Raspberry Pi Pico

First seen in

Thonny UI
- Install firmware
- Save and run files
- Explore the microcontroller
  - Locate GP pins
  - Use the onboard LED
- Connect to a computer
- Use a socket-socket jumper wire
  - Use a pin-socket jumper wire
- Connect an LED and a resistor
  - Connect a switch

The Raspberry Pi Pico

Hardware components
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- Scratch
- Python
- Raspberry Pi Pico
- Unity
- Web

Introduction to Scratch: sprites, scripts, and loops

Introduction to Python: Variables, functions, and loops

Introduction to Raspberry Pi Pico: LEDs, buzzers, switches, and dials

Introduction to Unity: 3D Objects, Character Controllers, Text and Buttons

Other levels available!

rpf.io/paths
We aren’t done yet!

More research
More tools
More libraries
Greater accessibility
What do We Know about Computing Education for K-12 in Non-formal Settings?

Systematic Literature Review of Recent Research
https://rpf.io/nfc (Open Access)

Tracy Gardner, Hayley C. Leonard, Jane Waite, Sue Sentance

18th ACM Conference on International Computing Education Research (ICER 2022)

**Aim:** Provide an overview of recent research and provide a starting point for more rigorous research.
Scope and research questions

We included 88 papers

✓ Non-formal education
✓ Age 5-18
✓ At least 5 hours
✓ Physical setting
✓ Computing focus
✓ Substantive impact data
✓ 2015 - March 2021

▶ **RQ1**: What has been the focus of non-formal computing education research? Learners, providers, topics, measures.

▶ **RQ2**: What is the impact of non-formal computing education on learners? synthesis
Systematic review to avoid bias

421 Results from keyword and abstract search

Inclusion/Exclusion Criteria Applied

181 Articles Retrieved

Inclusion/Exclusion Criteria Applied

240 Articles Excluded After Title/Abstract Screen

75 Articles Excluded After Full Text Screen

18 Articles Excluded During Data Extraction

88 Articles Included
Example included papers

- Dynamics of emotion, problem solving, and identity: Portraits of three girl coders
  Maggie Dahn & David DeLiema

- Identifying Pathways to Computer Science: The Long-Term Impact of Short-Term Game Programming Outreach Interventions
  Antti-Jussi Lakanen and Tommi Kärkkäinen

- Computing Education for Intercultural Learning: Lessons from the Nairobi Play Project
  Ian Arawjo et al.

- Making Apps: An Approach to Recruiting Youth to Computer Science
  Jody Clarke-Midura and Chongning Sun, Katarina Pantic

- Empowering middle school girls to create data-enabled social apps
  Lijun Ni, Farzeen Harunani, Fred Martin
RQ1: What has been the focus of non-formal computing education research?

- **USA**: Mostly USA
- **Other**: Mostly middle school
- **More female only cohorts**: Focus on broadening participation
- **Lack of detail on socio economic status**: Lack of focus on disability
RQ1: What has been the focus of non-formal computing education research?

Most studies were university organised.

Some studies by non-profit organisations, tech companies, makerspaces, etc.

Most studies took place in immersive multi-day settings (e.g. summer camps).

Most common purposes: Broaden participation and interest development.

Providers and purpose
RQ1: What has been the focus of non-formal computing education research?

- Game development
- App development
- Programming

Computing topics
RQ1: What has been the focus of non-formal computing education research?

**Cognitive**
- ** Constructs:** knowledge and skill development
- **Data:** pre-post tests, artefact evaluation and focused case studies

**Affective**
- ** Constructs:** interest, perception, engagement, self-efficacy
- **Data:** Surveys and interviews and focused case studies

**Outcome measures**
RQ2: What is the **impact** of non-formal computing education on learners?

**Cognitive** - broadly positive

- Some evidence regular settings were beneficial for knowledge development
- Active teaching of problem solving skills can lead to independence
- Learning gains were similar for male and female cohorts but some evidence of higher scores for boys

**Case studies** increase understanding of the *learning trajectory*. 
RQ2: What is the impact of non-formal computing education on learners?

**Affective** mostly positive in the short term

- Improved perception and awareness of computing
- Improved confidence and self-efficacy unless mismatched with prior experience
- Positive benefits from social factors: belonging, support, mentor relatability

**Case studies** increase understanding of the emotional journey.
Discussion: Affordances of non-formal computing

- Access and awareness
- Cultural relevance and equity
- Practice and personalisation
- Fun and engagement
- Community and identity
- Immediate impact

Complements formal education
What *don’t* We Know about Computing Education for K-12 in Non-formal Settings?

- USA
- Non US settings
- Primary/elementary school
- Detailed demographic data
- Regular meetups/sessions
- Disability
What **don’t** We Know about Computing Education for K-12 in Non-formal Settings?

Longitudinal studies measuring impact

Computing beyond programming

Which specific factors contribute to positive outcomes

Replicable studies
What next?
What next?

Research study
To help fill in the gaps

Research informed
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321 Make! in practice
Discussions
Discussion prompts

1. Should non-formal learning focus on making it easier to make things that matter to young people?

2. How can we better support young people in non-formal settings around the world with different cultural norms and education systems.
References

1. 321 Make! Paths
   rpf.io/paths

2. 321 Make! mentor guide
   rpf.io/321-make

3. What do We Know about Computing Education for K-12 in Non-formal Settings? A Systematic Literature Review of Recent Research
   rpf.io/nfc