TEACHING COMPUTING IN SCHOOL: IS RESEARCH REACHING CLASSROOM PRACTICE?

Koli Calling Keynote
November 18th 2021

Sue Sentance

Raspberry Pi Computing Education Research Centre
Department of Computer Science & Technology, University of Cambridge
& Raspberry Pi Foundation, Cambridge, UK

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@suesentance

The 30-second version of my talk

To ensure our computing education research can have an impact on classroom practice ….

… we need to understand knowledge mobilisation, which can take the form of transfer, translation or transformation

I'll be sharing some general approaches and specific examples and trying to explore whether they involve transformation of knowledge

And I'd like to stimulate some discussion about your own examples, in higher education as well as K-12

Overview

- K-12 Computing Education Research
- Research to Practice & Knowledge Mobilisation
- Looking through different lenses
- Activities to support research having impact in the classroom
- (Seven) Case studies
- Questions and discussion!

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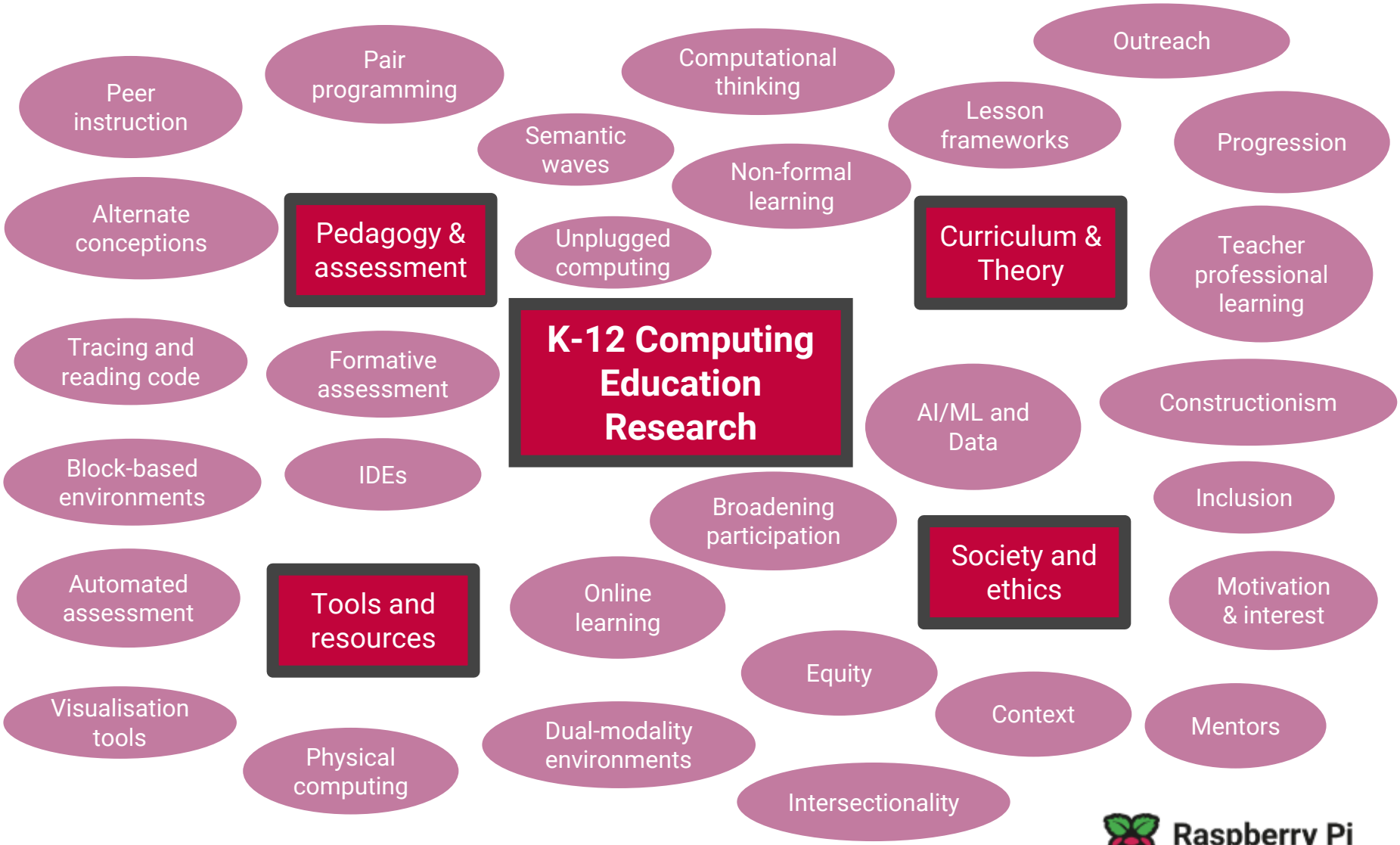
K -12 Computing education research is a broad field



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Themes around the research-to-practice discourse

Evidence-based practice in education / computing education

Across K-12 education in general

- There has been a considerable government interest in evidence-based practice in education in UK and Europe
- In 2013, the UK invested £135m over 10 years in evidence-based practice in education as part of the development of a series of “What Works” centres around social policy
- In 2010, 33% of teachers in England had undertaken some sort of research and enquiry to improve their practice (Cain, 2015)
- A focus on making research open-access means that it’s more accessible to teachers

In K-12 computing education

- Increase in schools and jurisdictions teaching computing at K-12, globally (Vegas et al, 2021)
- Teacher professional development needs moving from focus on subject knowledge to “what teaching methods are effective?”
- Increased resources / funding for K-12 CER (NSF, EU)

Are the findings from research making their way to the classroom?

Some themes for policy makers / educationalists

- Can the medical model of evidence-based practice be applied to education?
- Are the research methods most touted by policymakers (eg RCTs) the most appropriate or sufficient?
- What motivates teachers to implement research that they have come across?
- Who can help support implementation of research (researchers, school leaders, district leaders, teachers)
- What is the role of the research producer or research user?
- What activities best lead to research-informed practice?
- **Can research-generated knowledge be implemented in practice?**

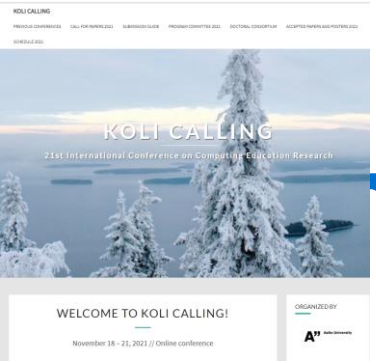
(From Cain, 2015, but reworded)

Research to Practice: the time lag

In medicine it take 17 years on average for research findings to reach clinical practice
(Morris, Wooding and Grant, 2011)

Research

Practice



In education …

"Our conversations with researchers, practitioners and policymakers have shown that they do not have shared priorities, although there are areas of common concern or interest. This causes disconnects between supply and demand, and contributes to a lack of sustained research effort." (The Royal Society, 2018, Harnessing Educational Research)

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Research to practice: the process

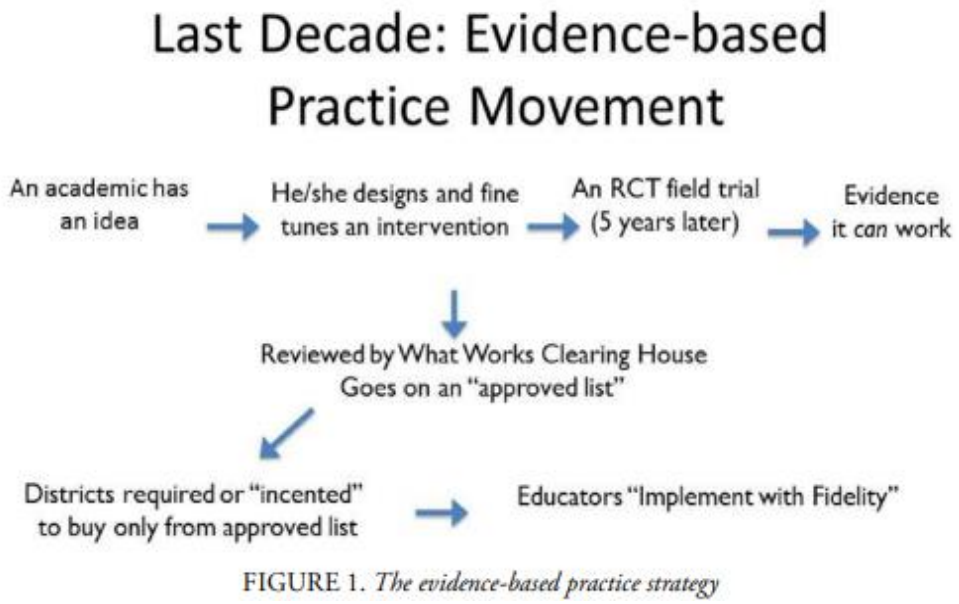
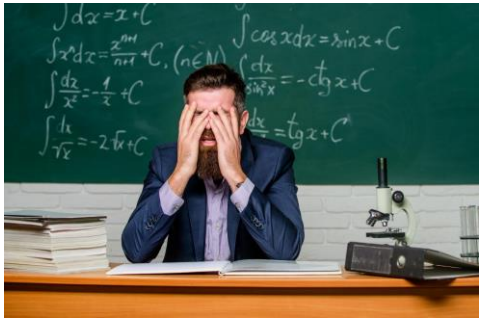


FIGURE 1. *The evidence-based practice strategy*



From Bryk, Anthony S. 2015. "Accelerating How to Learn to Improve." *Educational Researcher* 44 (9): 467–477. (page

". . . research can never tell teachers what to do. Indeed, given the complexity of classrooms, it seems likely that the positivist dream of an effective theory of teacher action—which would spell out the 'best' course of action given certain conditions—is not just difficult and a long way off, but impossible in principle." (Wiliam, Lee, Harrison, & Black, 2004, p. 51)

Knowledge mobilisation

Knowledge mobilisation is *'the process through which research and data become integrated (or fail to become integrated) into educational policies and practices*.' (Cooper, Klinger, McAdie, 2017)

Three types of knowledge mobilisation (Carlisle, 2004):

- Knowledge transfer
- Knowledge translation
- Knowledge transformation

Research may generate knowledge that something can work – but teachers need knowledge of how to actually make it work reliably over diverse contexts and populations (Byrt, 2015).

Knowledge generated by research	Teachers' pedagogical knowledge
Propositional & theoretical knowledge	Procedural & practical knowledge
Generalized, abstract and impersonal	Context-specific, based on personal values
Narrowly-focused on single, isolated issues	Broadly focused on many issues
Accumulated slowly and logically, with an attitude of principled skepticism	Knowledge that informs intuitive, tacit, swift and fluent thinking
Valued for its significance, originality and rigour	Valued for its practicality and fitness for purpose

"Despite the increased interest in research impact, there is very little empirical evidence that educational research can inform practice directly, and furthermore, a body of literature which suggests that this is, in principle, impossible." (Cain, 2015)

Enlightenment

Enlightenment is teachers' interpretation of research and their ability to embed it in their practice,

- Strong enlightenment provides a comprehensive world view that should govern practice
- Moderate enlightenment recognises the fallibilistic and qualified nature of research (Hammersley, 2002).

The teacher may operate as a 'professional technician' who "*investigates and interpret research and incorporate it into their practice if they are satisfied that it is the best way of achieving their ends.*" (Winch, 2017, p. 147) – an example of moderate enlightenment

Knowledge transformation involves 3 types of thinking (Cain, 2015):

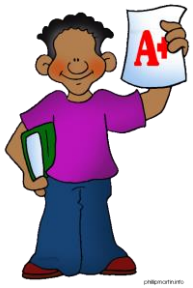
- conceptual development,
- reflection on cases drawn from personal experience, and
- the imaginative diffusion of research knowledge into areas beyond those originally researched.

As computing education researchers, how can we facilitate these three types of thinking in the way we disseminate our research findings and work with practitioners?

Research to practice from different perspectives

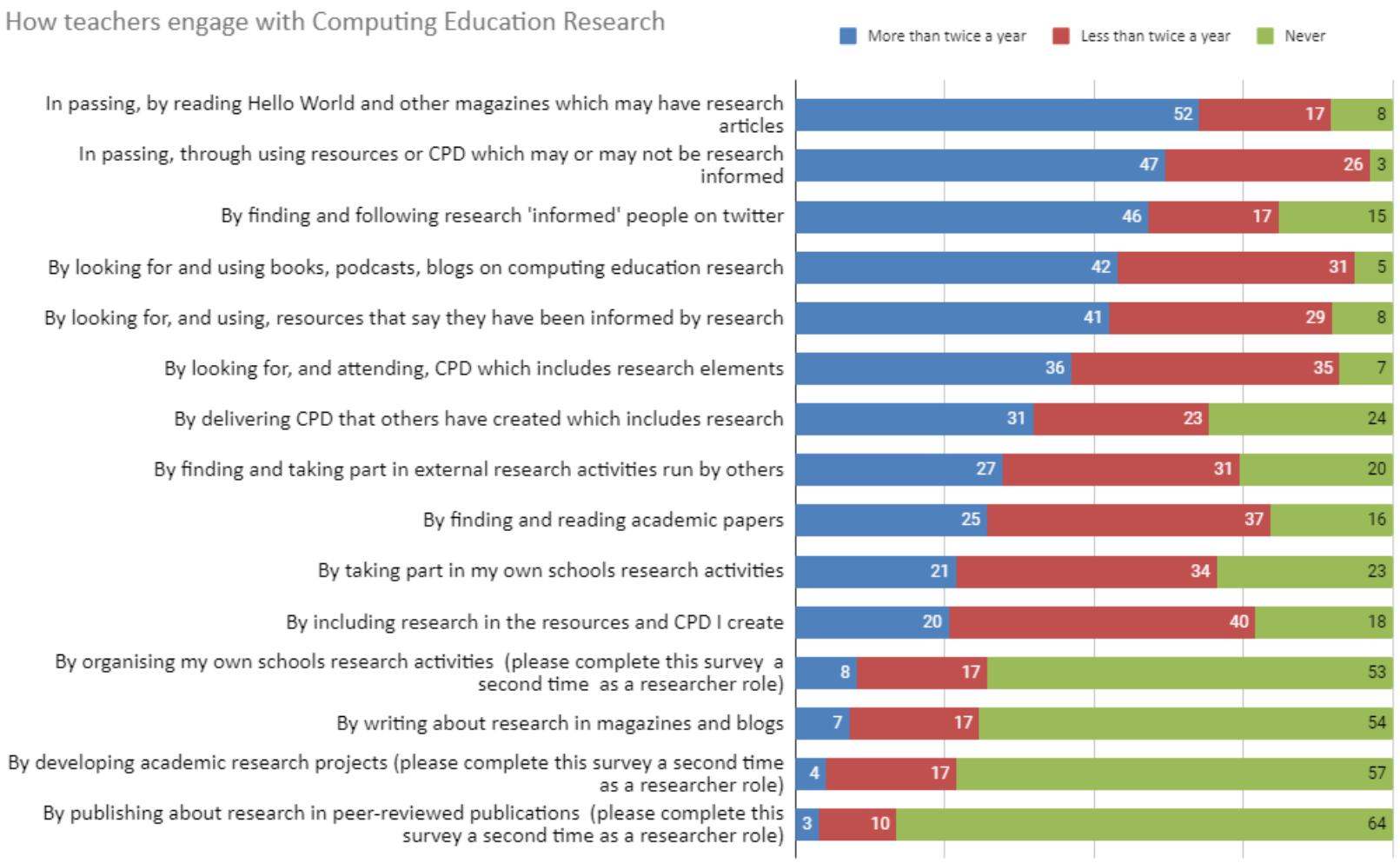
Different perspectives

What's the value of research in education?



The school's / teacher's perspective

How teachers engage with research



CPHC (2021). Schools and universities, how do they work together to support the teaching and learning of computing? Report available at https://cphc.ac.uk/publications/reports/

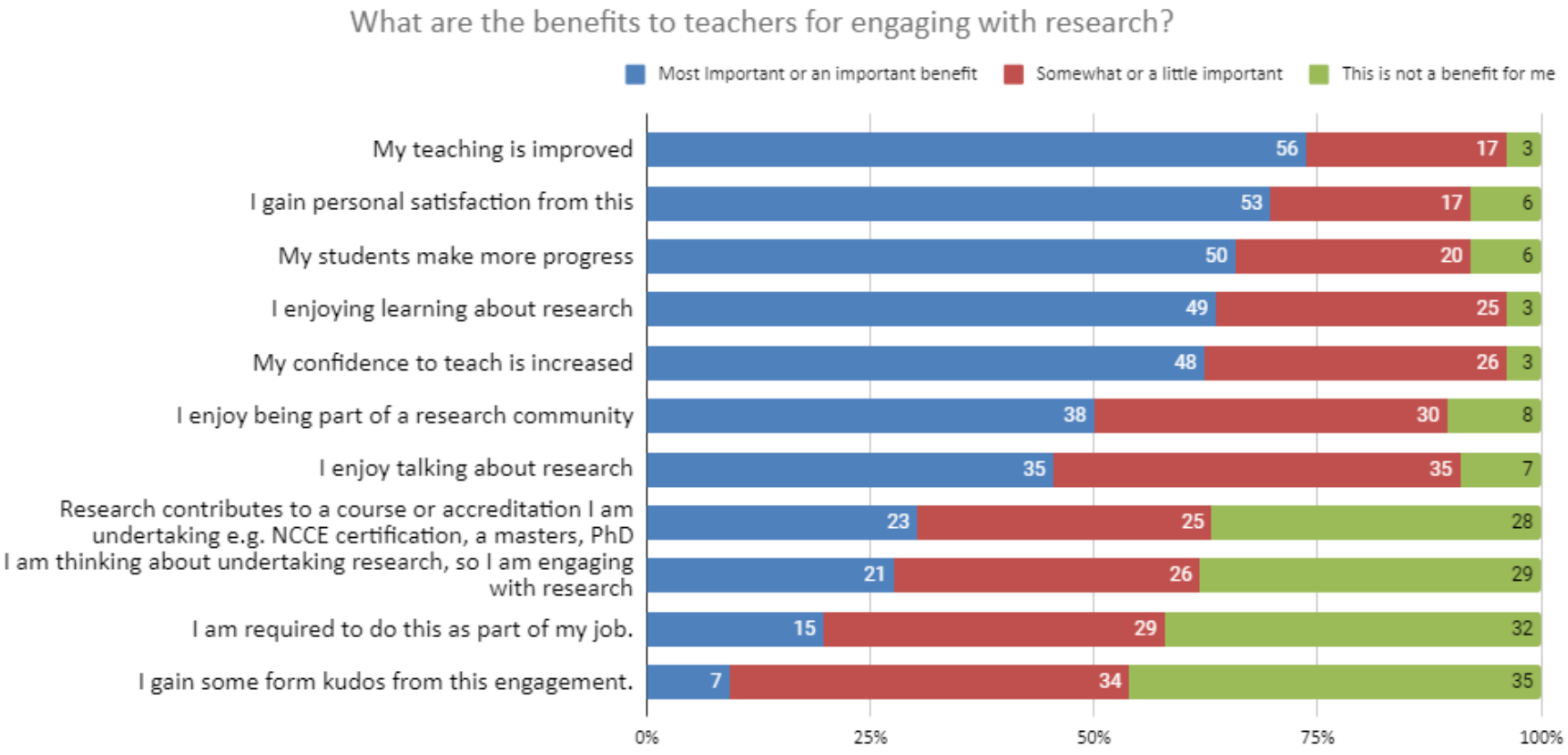
Approaches to engagement

Levels of engagement by teachers in research

Stereotype	Dispositions	Goals	Activities
Research aware "looking for practical ideas"	• professional integrity • reflective practitioner	• find evidence-based practice • develop knowledge of subject • develop pedagogical subject knowledge	• read and apply information & advice • participate in CPD • attend TeachMeets and share
Research literate "developing knowledge"	• curiosity • scepticism • open mind	• judge validity, reliability, ethics • aware of research scene	• participate and contribute to research • attend conferences to join in • apply to policies
Research active "answering new questions"	• action • deeper / wider interest • organiser	• know methodology • involved in research scene	• lead research • attend conferences to present • publish

Millwood, R. (2019). What influences teachers' uptake of research informed practice. Blog post.

Benefits to teachers for engaging with research



CPHC (2021). Schools and universities, how do they work together to support the teaching and learning of computing? Report available at https://cphc.ac.uk/publications/reports/

The researcher's perspective

The researcher's perspective

- Researchers seek deep understanding of matters which have theoretical value
- Our success is measured by peer-reviewed papers, often incomprehensible to the lay person, must adhere to the standards of the academic community (Hammersley, 2002)
- Research generates propositional knowledge, but teachers need knowledge of how to do things (McIntyre, 2005)
- Researchers may work with a school to conduct an intervention, measure the impact, discuss with teachers, then not return later to see what happens - or try in other contexts
- Computing education at K-12 is a young field – we need to build theory and models on a small scale, test robustly, and develop criticality before being confident about large-scale implementation

Knowledge generated by research
Propositional & theoretical knowledge
Generalized, abstract and impersonal
Narrowly-focused on single, isolated issues
Accumulated slowly and logically, with an attitude of principled skepticism
Valued for its significance, originality and rigour

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The policy/funders' perspective

Teaching and Learning Toolkit

An accessible summary of education evidence

Watch the Toolkit explainer | Read our guide to using the Toolkit

Implementation cost £ £

Evidence strength

Impact (months) + +

Search by keyword

Toolkit Strands	Cost	Evidence	Impact
Arts participation Moderate impact for very low cost based on moderate evidence	£		+3
Aspiration interventions Unclear impact for very low cost based on insufficient evidence	£		
Behaviour interventions Moderate impact for low cost based on limited evidence	£ £		+4
Collaborative learning approaches High impact for very low cost based on limited evidence	£		+5
Extending school time Moderate impact for moderate cost based on limited evidence	£ £ £		+3

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Differences in perspective

“ In reality, policymakers, researchers and teachers are all influenced by underlying personal beliefs about what education ought to be about and how it fits into a wider world view. It would be naïve to suggest that the relationship between research and policy is either straightforwardly pragmatic or unaffected by party political preferences and prejudices.”

(The Royal Society, 2018).

The Royal Society’s Harnessing Educational Research report recommended that:

- Teachers (often mature learners) were enabled to study for masters’/doctoral degrees in education part-time
- Teachers were supported to use research in teaching through initiatives such as Research Schools, and the importance of research-informed practice was recognised in schools
- Interaction is facilitated between policymakers and researchers, to encourage flow of information and ideas, including overcoming cultural barriers, and political and ideological resistance
- Researchers should get more recognition for the expertise needed to create high-quality syntheses

Activities that may support links between research and practice

Supporting research -> practice links

Translational research

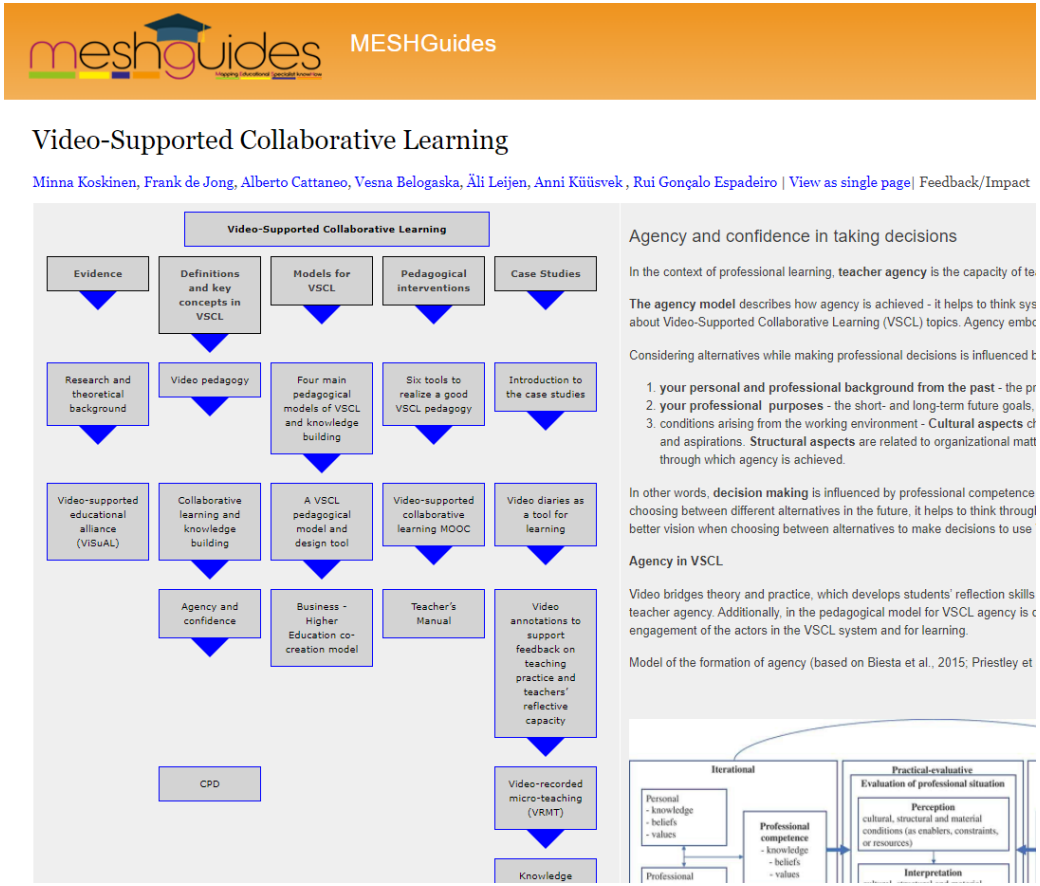
Translational research is "*the movement of available research knowledge into active professional use*" (La Velle, 2015)

It attempts to bridge the gap between basic research and the world of practice. .

Can take different forms:

- Translating research to lessons for practice
- Providing research in a range of different formats

Translational Research – an example



- Systematic reviews conducted about specific fields of enquiry
- Highly synthesised
- Researcher uploads to MESH system
- Teachers can click on the area that they are interested in.

(Jones et al, 2015).

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Supporting research -> practice links

Translational research

Research-informed educational programmes

Some research may stimulate educational programmes based on the research, normally where:

- The research suggests improvements could be made across the school population
- There is buy in from education policy-makers and government/

Examples might be:

- How to teach reading
- How to teach mathematics
- Assessment for learning

Idea that “effective interventions * effective implementation = improved outcomes” (Fixsen et al, 2013)

Resources and training programmes may also be developed that embed a particular approach

Supporting research -> practice links

Translational research

Research-informed educational programmes

Research-practice-partnerships (RPPs)

- Research-practice partnerships are long-term, mutually beneficial collaborations that promote the production and use of research.
- $60m investment in the US. Anywhere else?
- Studies have "*less prescriptive research designs and methods, with research occurring in rapid, iterative and context-expanding cycles*." (US NSF)
- Excellent summary by Monica McGill et al in recent ACM InRoads magazine!
- Similar to less formal work done elsewhere where universities/researchers work in partnership with schools

Supporting research -> practice links

Translational research

Research-informed educational programmes

Research-practice-partnerships (RPPs)

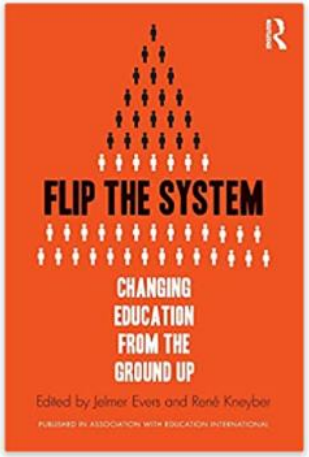
Practitioner research

- Teachers engaging in action, classroom-based or practitioner research
- Researching a real, contextualised problem in the classroom
- Decades of research has shown that this is invaluable professional development
- Research findings are small-scale, may not be rigorous, but demonstrate iteration through the action research cycle

"*Action research enables teachers to reflect on their practice to improve it, become more autonomous in professional judgment, develop a more energetic and dynamic environment for teaching and learning, articulate and build their craft knowledge, and recognize and appreciate their own expertise*." (Pine, 2009)

Supporting research -> practice links

- Translational research
- Research-informed educational programmes
- Research-practice-partnerships (RPPs)
- Practitioner research
- ‘Flip the system’



- Argues for the role of the teacher in changing education
- Use school data for research
- Original book edited by Jelmer Evers and René Kneyber but there are now country versions.
- Led to teacher-research conferences such as ResearchEd

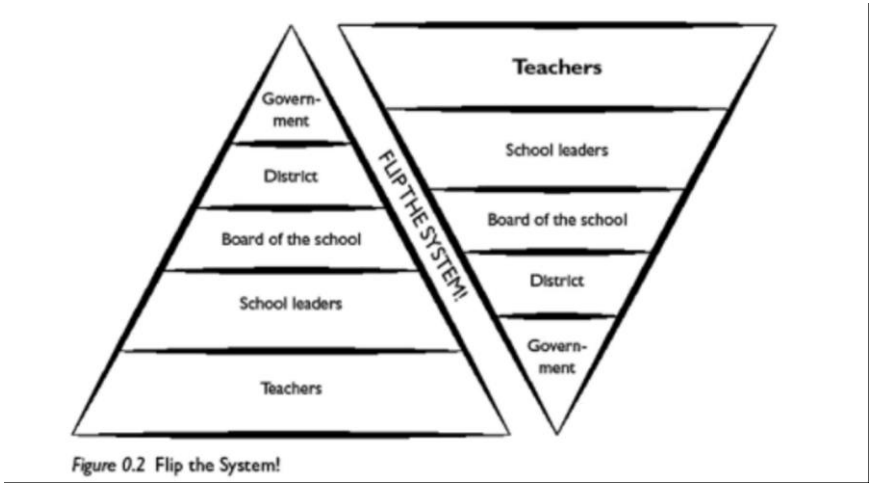
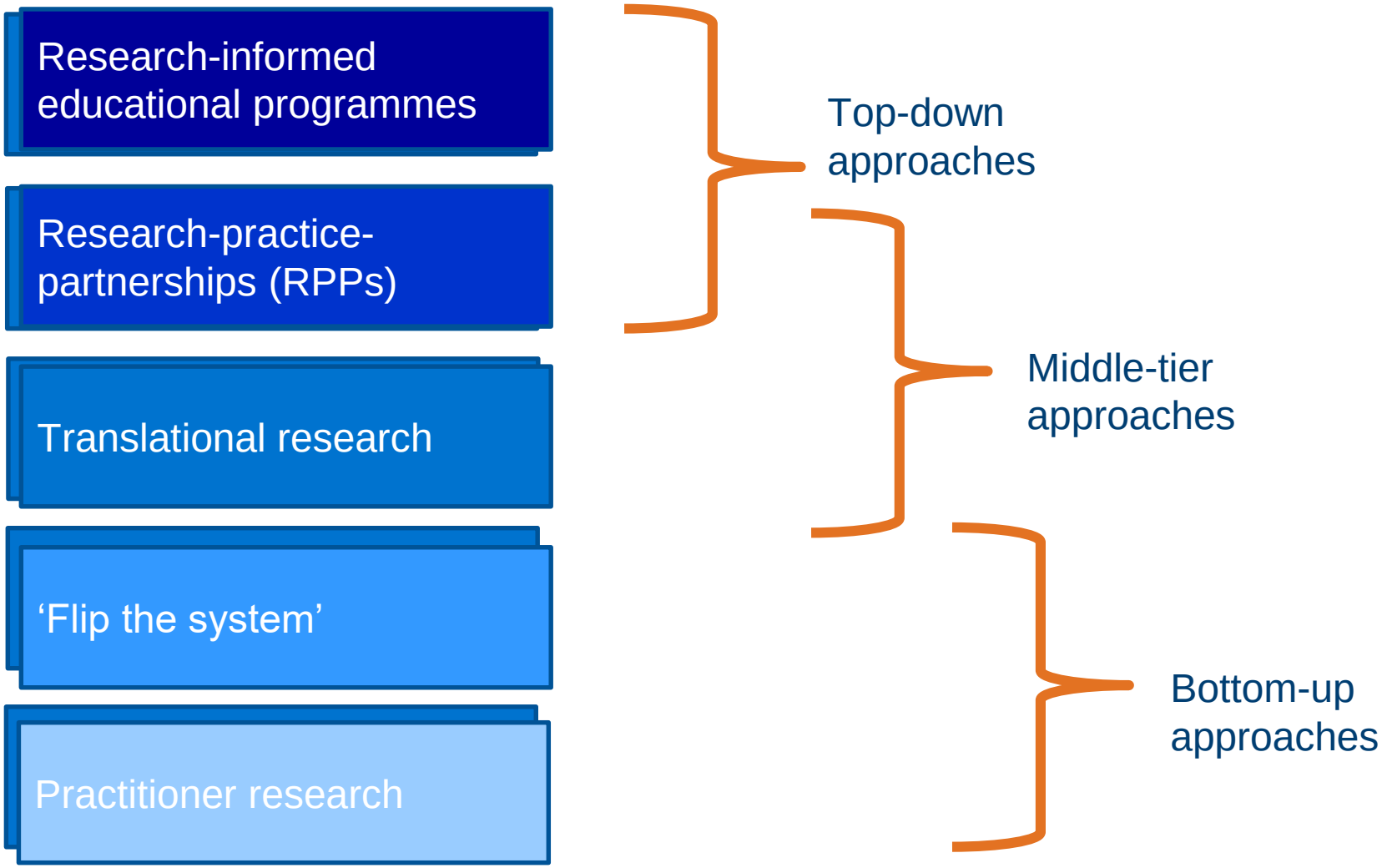


Figure 0.2 Flip the System!

“In summary, it is clear that the neoliberal shift in reform has led, in a more postmodern sense, to the death opf the teacher: the death of the very idea that a teacher has something to contribute, the very idea that the teacher has a meaningful voice in regard to his work, to what he wants to achieve through his work and by which means he achieves it.” (Evers and Kneyber, 2015).

Linking research -> practice



Some examples

Some case studies from England / my experience

National Centre for Computing Education

1. Pedagogy Quick Reads and other outputs
2. Teach Computing Curriculum

3. CAS (Computing At School) Research
4. PRIMM
5. Research Seminars
6. Teaching Inquiry in Computing Education
7. Localising culturally relevant pedagogy research for UK schools

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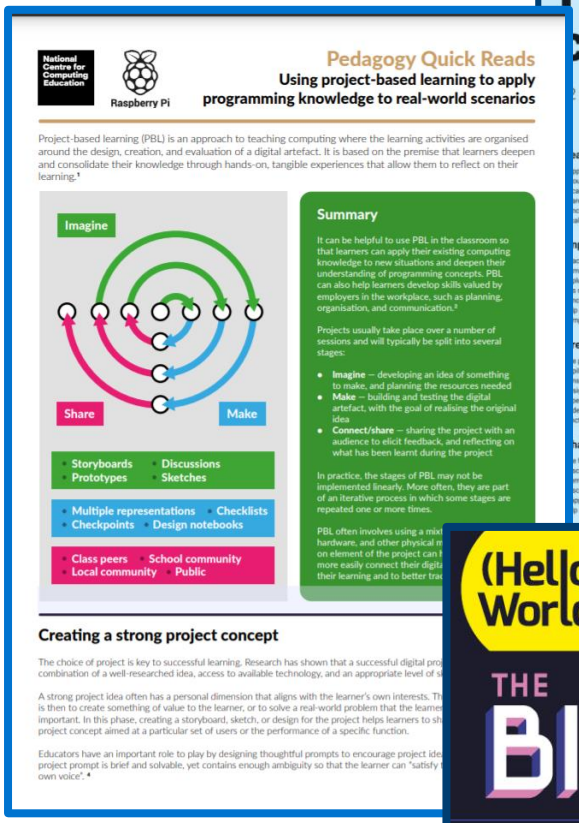
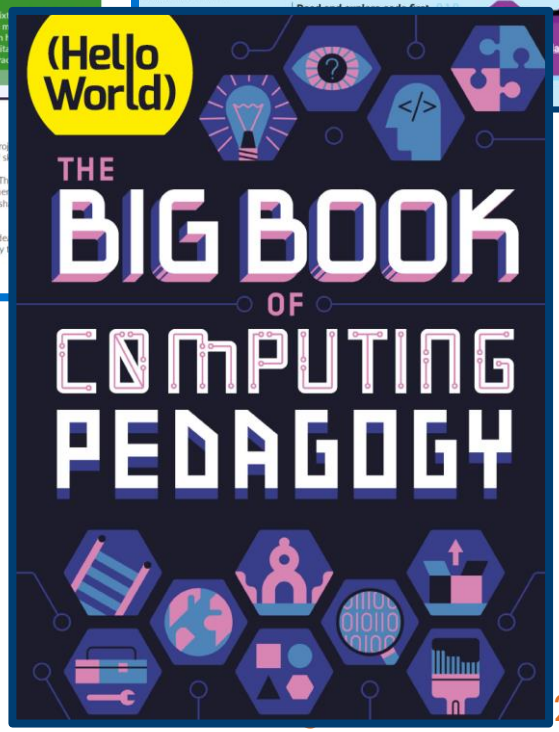
Case Studies [1]: Pedagogy Quick Reads

- Series of pedagogy outputs – part of government-funded NCCE programme
- 2 page, A4, pedagogy “Quick Reads” in topics including:
  - Cognitive Load
  - Project-based learning
  - Code tracing
  - The Block Model
  - Semantic waves
  - Peer instruction
  - Pair programming
  - Worked examples
- Research Bytes newsletter sharing new research and stories of teachers use of it in the classroom
- Podcasts sharing research topics and teachers’ experiences in the classroom





“I think the quick reads are excellent and in-fact the whole pedagogy section of the the website.” (Teacher, survey response)

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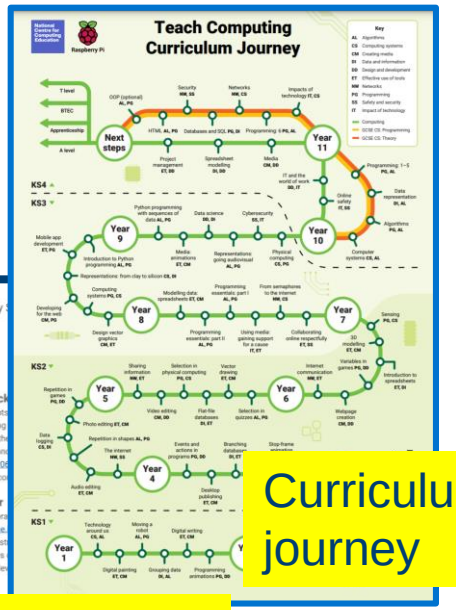
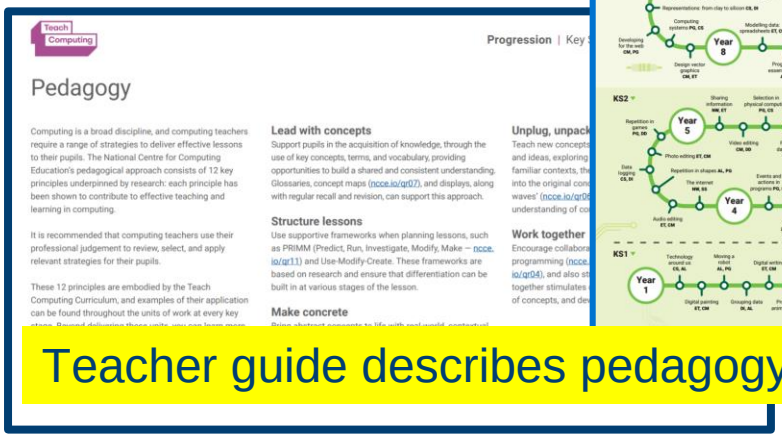
Case Studies [2]: Teach Computing Curriculum

- Full computing curriculum funded by the Department of Education in England as part of the NCCE
- Embeds the 12 research-informed pedagogical principles drawn from work with teachers, researchers and stakeholders
- Pair programming, semantic wave theory, levels of abstraction, PRIMM, etc. are embedded into lesson plans, slide shows, activities and homework assignments
- Lessons are sequenced from age 5-16 and mapped to the curriculum
- Teacher guides explain the approaches taken and provide links to pedagogy outputs (previous slide)

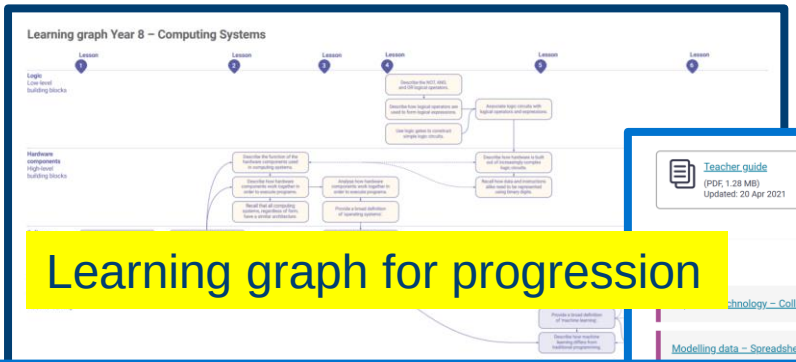
From September to October 2021 there were c.110K unique lesson downloads globally (c.80K in England)



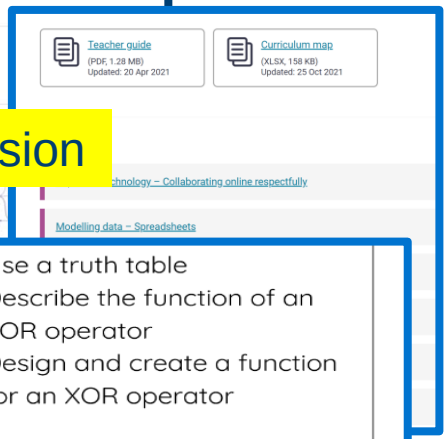
Curriculum journey



Teacher guide describes pedagogy



Learning graph for progression



Lesson 21: XOR	Learners were introduced to logic operators in Lesson 10. At that point, they could only use AND and OR. Learners also need an understanding of how the XOR operator works. Python doesn't have an XOR operator, so ... Learners will ... truth tables. They will learn about XOR, and complete a truth table for the operator. Next, they will ... creating a function for an XOR operator using worked examples for support.	• Use a truth table • Describe the function of an XOR operator • Design and create a function for an XOR operator

Unit guide highlights pedagogy being used

Case Studies [3]: CAS Research Group

- Meetings with teachers started 2014
- Linking teachers with a network of universities

- Developed into a research stream for the annual CAS teachers' conference (research summaries and plan-your-research workshops)
- Sharing existing research to enable teachers to become research-engaged
- Supporting teachers wishing to become research-active
- Enabling collaborations between universities engaged with research in computer science education in school
- More recently (since pandemic) F2F meetings went online and became a monthly book club for teachers to join and become involved in

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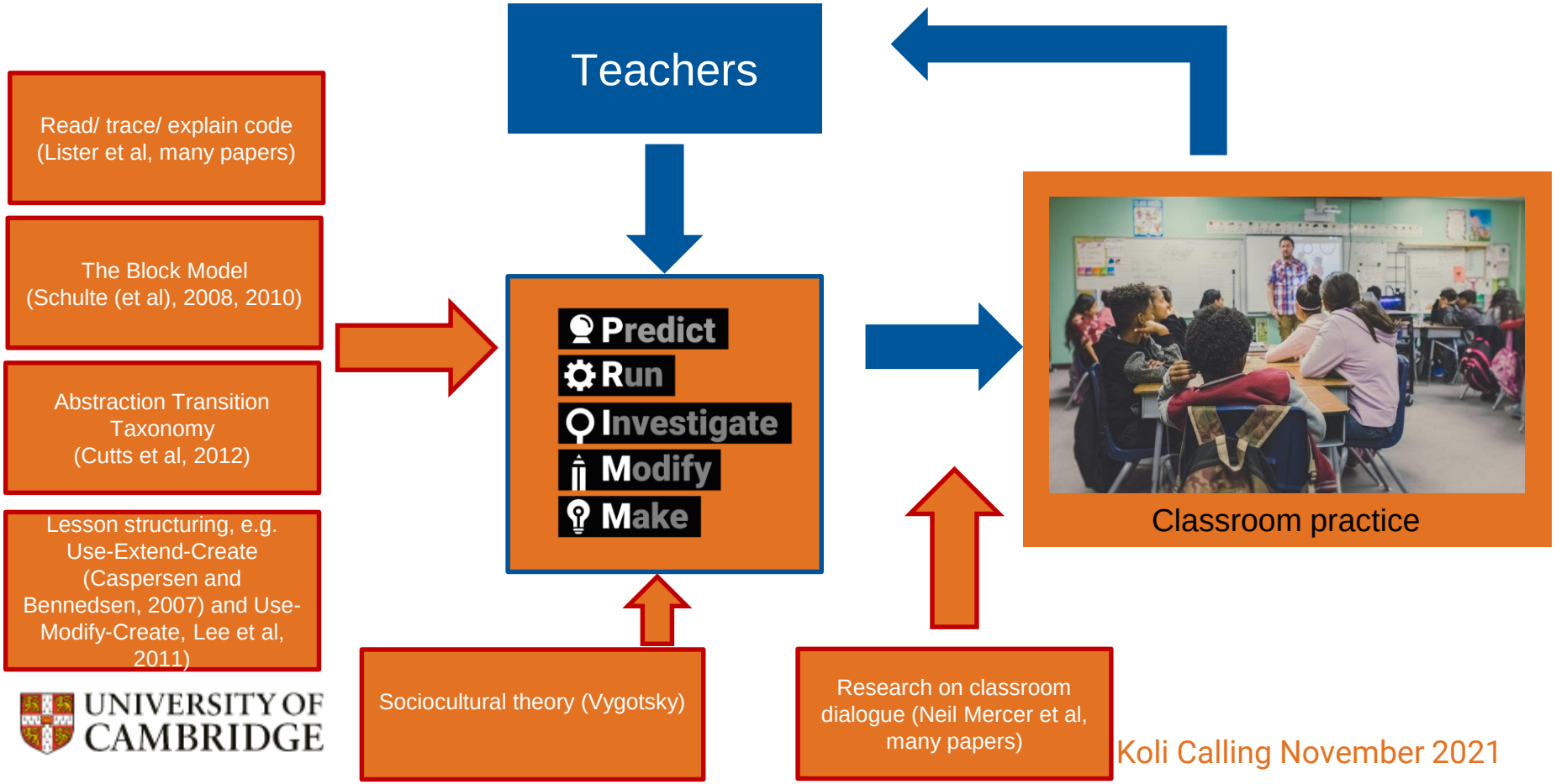
Case Studies [4]: PRIMM for structuring programming lessons

- PRIMM is an acronym to help teachers in school structure their programming lessons
- PRIMM stands for Predict-Run-Investigate-Modify-Make and builds on previous research by others
- Developed in conjunction with teachers, pre-service teachers, own experience, and drawing on research, *in response to a recognised need*.
- PRIMM approach adapted with feedback from teachers



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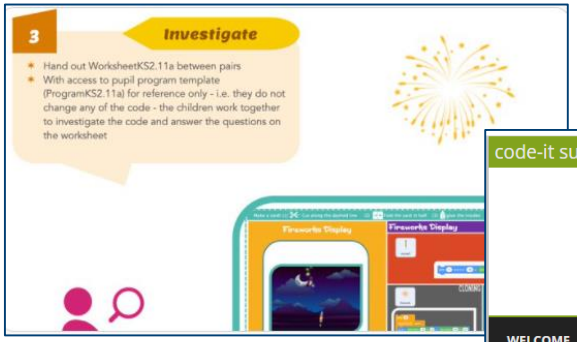
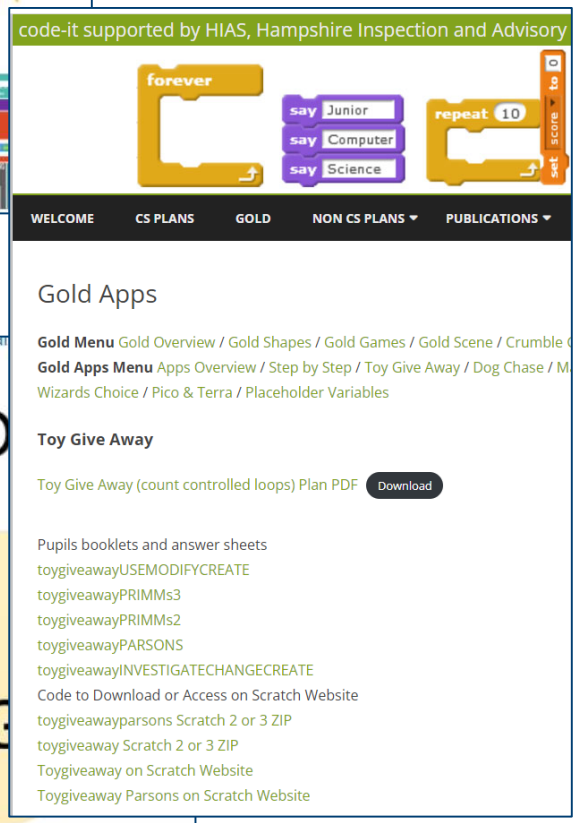
What we've learned from PRIMM in the classroom about knowledge mobilisation

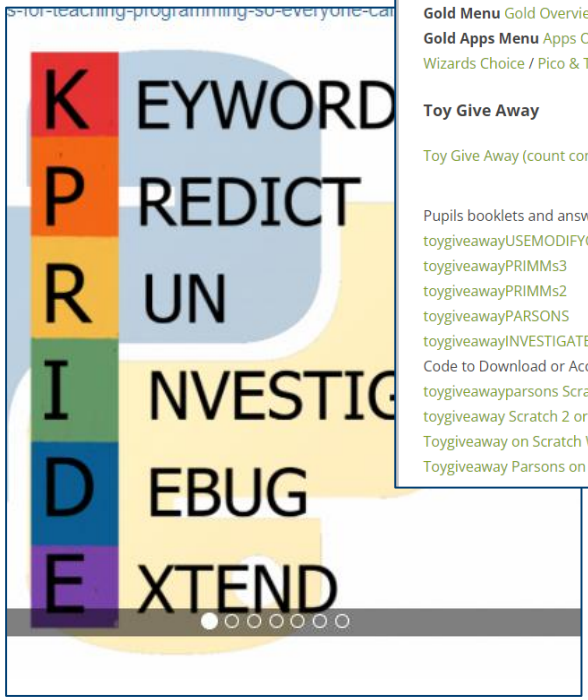
- Other teachers take the research resources as-is and use to supplement their own work **(transfer)**

- Other teachers have developed sets of PRIMM-inspired resources that other teachers can use directly in their classroom for age groups not covered by the research (specifically primary, but also 14-16) **(translate)**

- Some teachers have taken the ideas and transformed them into something that works for them: K-PRIDE, EPIC, TIME and T-PRIMM, for example **(transform)**







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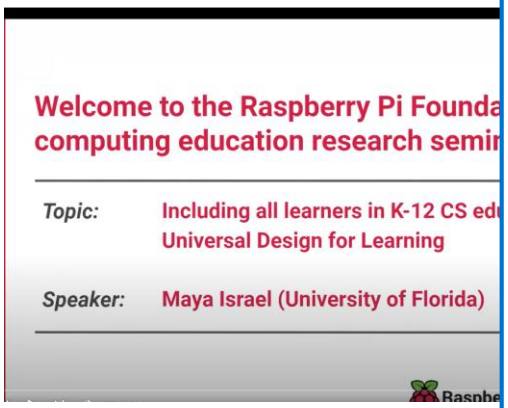
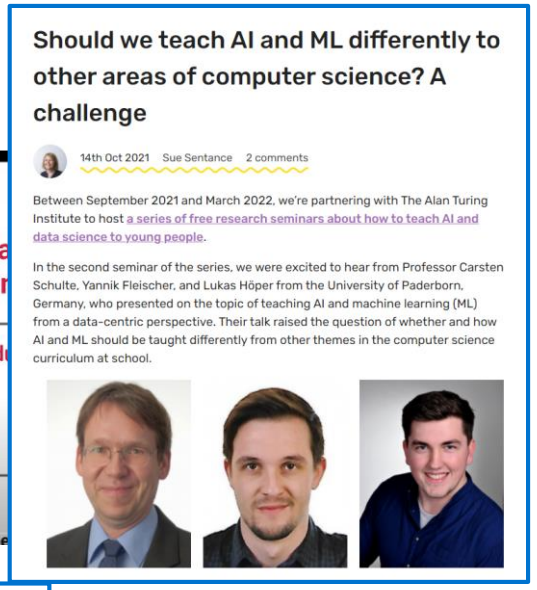
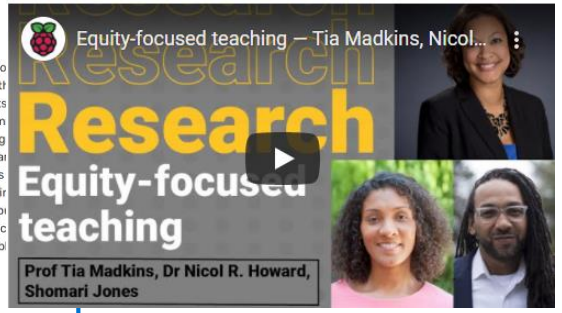
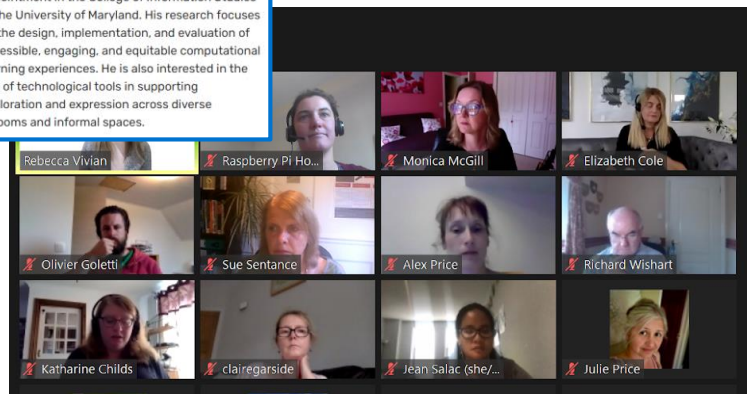
Case Studies [5]: Research Seminars

- Monthly seminars on current research topics in computing education
- Attended by teachers and researchers who discuss topic together in groups afterwards
- 22 seminars held on topics from block-based programming to teaching AI to equity-based classroom practice
- Disseminated through catch up videos, blog post, slides, and proceedings: providing access to research with a low bar
- Benefits researchers (their work is widely disseminated to potentially a new audience) and teachers (access to research more easily than reading a long paper).









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Case Studies [6]: Teaching Inquiry in Computing Education

- Action research programme 2015-2016
- Teachers met to decide on RQs and plan research
- For 6 months carried out small projects supported by volunteer academics
- Teachers met again to analyse data and plan write ups
- Streamlined (minimised) writing up generating posters, presentations and booklets of research shared with schools
- Sentance, S., Sinclair, J., Simmons, C., & Csizmadia, A. (2018). Classroom-based research projects for Computing teachers: facilitating professional learning. *ACM Transactions on Computing Education (TOCE)*, *18*(3), 1-26.


COMPUTING AT SCHOOL
EDUCATE · ENGAGE · ENCOURAGE
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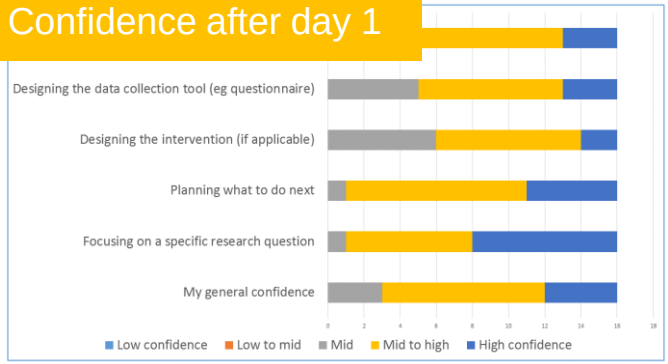
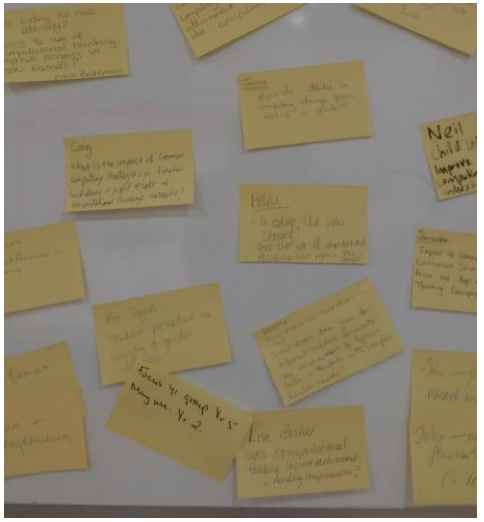
ASHLEY COLLEGE
Deborah Thompson
How does the use of defusion, hard copy media and online interactive software help students with complex health needs to develop their programming skills
Outline of the project
Motivation
Students with health needs often miss out on educational opportunities. I believe that these students deserve the opportunity to do well. My research was designed to find out whether hard copy and online interactive software such s codecademy, best facilitated thelearning and developing of their python skills.
Research questions
How does the use of hard copy, on line media and defusion, facilitate the development of Python skills in students with complex health needs?
About me
My name is Deborah Thompson and I have been a teacher for over 20 years. I have been teaching Computer Science GCSE for 3 years.
Carrying out the research project
Your intervention
Students were given a hard copy learning resource and access to an online learning site, each for 10 hours. After using these resources students were asked to
Data collection
I designed a questionnaire which asked students to evaluate their experience using Python programming from hard copy and online media, and to suggest any improvements which they thought





"The thing I found hardest was having to whittle down my great big question into one little realisable project. I'm very glad to have the chance of doing this research with guidance." (Teacher)

Case Study [7]: Localising Culturally Responsive Pedagogy research

- In the US, we have seen much research about culturally responsive computing teaching and culturally relevant pedagogy, accompanied by curricular and guidance for teachers
- For this research to be used by teachers, it needed to be localised to a UK context.
- A group of teachers and a few advisors (including Joanna Goode from US) met to produce a set of guidelines for teachers, as part of a SIGCSE Special Project Award.
- The next stage is to facilitate teacher-led workshops where the ideas from the research are implemented in classrooms in one area of England (funded by Google)
- An example of research being **transformed** through localisation to be useful in the classroom

Extracts from the guidelines created for use by teachers

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Wrapping up

Linking research -> practice

Research-informed educational programmes

Research-practice-partnerships (RPPs)

Translational research

‘Flip the system’

Practitioner research

Top-down approaches

Middle-tier approaches

Bottom-up approaches

Where do these examples sit?

Teach Computing Curriculum

New CRP Project

Research Seminars

Pedagogy Quick Reads

PRIMM

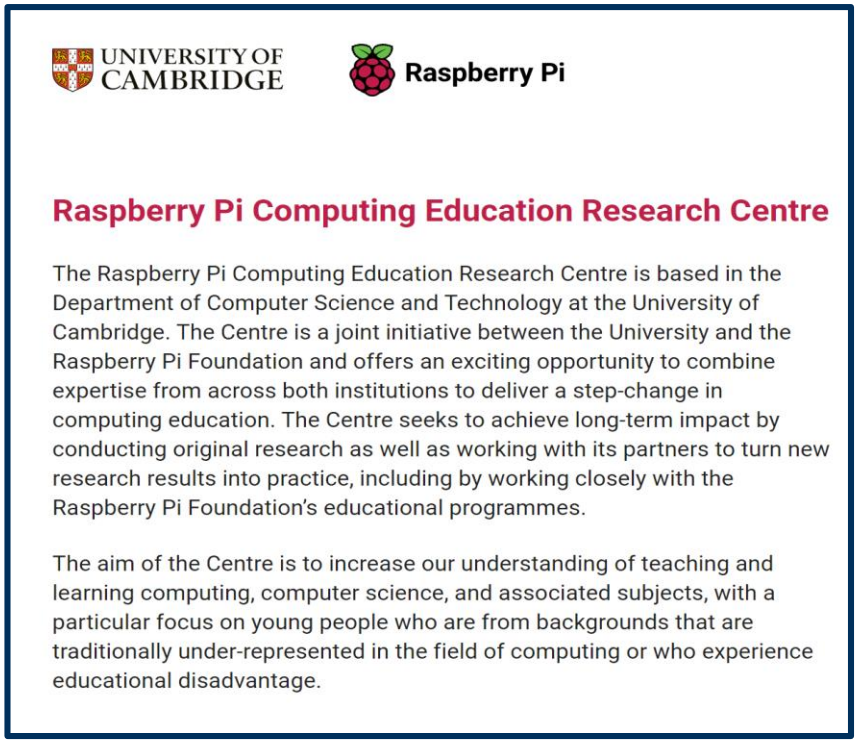
CAS Research

Teaching Inquiry Computing Education

Which examples demonstrate knowledge transformation?

What next?

- We need to understand knowledge mobilisation in the specific context of computing education
- How do we increase our understanding of the impact of different research-to-practice approaches?
- Continue projects that encourage knowledge transformation
- Continue, as researchers, to work closely with schools and teachers and disseminate our research in a number of different ways



Find out more about our work at:

- http://raspberrypi.org/research
- http://computingeducationresearch.org (the research centre)

PhD Studentships available – closing date 30th November 2021 (https://www.jobs.cam.ac.uk/job/31989/)

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Thanks for listening!

Discussion points… questions for you!

- How has your research been used in practice? Directly or indirectly/
- When is research not destined for practice?
- Is it the best and most solid research that ends up being adopted? (and if not, why not?)
- How can we effectively measure the impact of computing education research on student learning outcomes and practice?
- Is “translational research” valuable if we know that knowledge transformation works better than knowledge transfer?

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