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Constructionism at Scale: Some Thoughts on Evaluation

Education systems in the developed world might seem close to Papert's "tipping point' for meaningful learning with digital technology, in which schools have easy access to hardware, an awareness of the importance of the teacher's role, well-designed materials and syntactically meaningful programming languages. As Papert would have been first to acknowledge, the mere existence of hardware (or software) tells us little if anything about actual use in homes and schools, let alone any clear idea of what people might be learning as they interact with the computer. Still, we ought to be getting near the point at which we can say what remains to be done to bring out effective change in empowerment of learners and just ordinary folk?

But deciding how far we have been successful in implementing the constructionist vision inevitably raises a tricky problem. While it is relatively straightforward to identify performance in clearly pre-defined skills, it is much more difficult to do the same for necessarily open questions: How does programming (in Scratch) engage students in ways that supports them see learning as worthwhile? How do learners express themselves using Scratch? What can a Scratch-aware learner do that he/she couldn't have done without Scratch?'. Questions like this are hard to answer – we have been trying and will report on the outcomes of our endeavors.

It turns out that this is a problem for researchers in the scientific as well as social domains. For example, medicine – routinely regarded as the arena in which the most rigorous research is carried out, the 'gold standard' for research methodology – is facing much the same challenge. Here is the Medical Research Council in the UK, acknowledging that when dealing with complex interventions, one must be aware that:

Complex interventions are built up from a number of components, which may act both independently and inter-dependently. The components usually include behaviours, parameters of behaviours (e.g. frequency, timing), and methods of organising and delivering those behaviours (e.g. type(s) of practitioner, setting and location). It is not easy precisely to define the "active ingredients" of a complex intervention. For example, although research suggests that stroke units work, what, exactly, is a stroke unit? What are the active ingredients that make it work? The physical set-up? The mix of care providers? The skills of the providers? The technologies available? The organisational arrangements?

Medical Research Council, UK April 2000.

Educational interventions are certainly no less complex than this. So even before we reach the problem of pedagogy and change, we have to admit that it is difficult to be clear what are the key components of our complex intervention. Our contention is that to be clear about what, say, computational thinking is, presents us as constructionists with almost insurmountable difficulties!

Analysing change in what is to be learned is part of the constructionist agenda: Turkle and Papert's epistemological pluralism (1992) points to the irritating reality that even if we think we have identified some knowledge we are likely to overlook how that knowledge – and its 'acquisition' – may be reworked in constructionist practice. This is particularly hard when we are engaging with mathematics which is all too often evaluated high-stakes tests. We recall in the ICMI Study on Technology Revisited (Hoyles & Lagrange, 2010), that all participants were encouraged to reflect on the 10% of knowledge that would need to be rethought given the use of new digital tools. When using digital tools, what is changed in what the user needs to know mathematically? This quest was later abbreviated to 'Papert's 10%' and proved to be a worthwhile but extremely challenging task.

We would argue that the complexity of constructionist intervention is genuinely chaotic – in both the everyday and technical sense of the word. The point at which real change might occur (another tipping point?) is highly dependent on the initial conditions – and these are changing all the time. Imagine two perfectly-matched teachers, classrooms, students, physical setting and so on. In this perfect world, all is straightforward until one of the teachers decides to leave or the head teacher who had supported the intervention leaves. Not so bad surely? Everything else stays the same or nearly the same, doesn't it? But of course it doesn't – that is the nature of complexity. Before we know it, everything has changed and nothing is evaluable.

In a recent research project, we have built a Scratch-based mathematics (SM) curriculum comprising student detailed student activities for about 20 hours per year over two years along with teacher support materials and professional development days. SM has been implemented in over 100 schools across England aiming to promote mathematical thinking among students aged 9-11 years through programming. In seeking to evaluate SM we found ourselves asking: what exactly is a SM curriculum and how might its impact be evaluated? If we are able to decide if it works or not (which is hard), what are the active ingredients that (might) make it work? How far do we want teachers to implement the intervention exactly as designed (termed high fidelity) or how far do we want them to adapt it to suit their own purposed?

In the talk, we will describe the SM research in more detail and present some of the outcomes. In the process we have come up against some of the issues raised above that we will share in our talk. Finally, we discuss implications for sustaining and spreading coding as a modeling tool for learning more broadly – i.e. beyond mathematics.

About speakers

Celia Hoyles is Professor of Mathematics Education. Her role has varied hugely over the years but mainly concerns instigating, leading and fostering research and development in mathematics education. One enduring research interest has been the design of computer environments to engage students in learning mathematics.

She is working on two research projects at the moment: The ScratchMaths: supporting computational and mathematical thinking through programming, funded by the Education Endowment Fund and co-led with Professor Richard Noss, and Developing teachers' mathematical knowledge for teaching through computer-embedded activities with Dr Alison Clarke-Wilson funded by the Nuffield Foundation. So, both in primary and secondary schools she still strives for more engagement with mathematics through digital technology.

Richard Noss is Professor of Mathematics Education at the UCL Institute of Education. He was the founding director of the London Knowledge Lab, director of the government-funded Technology Enhanced Learning Research Programme, and deputy scientific manager of the EU Kaleidoscope network of excellence. Richard holds a Masters degree in pure mathematics and a PhD in mathematical education. He is an invited Fellow of the Institute of Mathematics and its Applications, a Fellow of the Academy of the Social Sciences and is a foreign fellow and medallist of the Union of Bulgarian Mathematicians. Richard was editor-in-chief of the International Journal of Computers for Mathematical Learning.