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Section: The Role of Leadership for Technology in Education

Teaching as a Design Science: Teachers building, testing and sharing pedagogic ideas

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A. What is it?

Educational researchers have tried hard to influence teaching, and with some success, but never with the resounding large-scale improvements that teachers and researchers all want to see (Morris & Hiebert, 2011). In part, this is because pedagogic content knowledge development "is a complex process that is highly specific to the context, situation, and person" (Van Driel & Berry, 2012). Teaching knowledge cannot be reduced to a set of guidelines, or captured on video by 'expert teachers'. These techniques may help, but they do not assure improvement.

On the other hand, our education systems could be seen as massive uncoordinated experiments, where every day, every teacher has the opportunity to try out and test new techniques, and learn from their students what works, and what does not. The idea of 'teaching as a design science' is to acknowledge, formalise and celebrate an approach to teaching that enables teachers to innovate, test and share their teaching knowledge.

Morris and Hiebert (2011) studied the working environment of other professional communities, such as medics and engineers, who share and build on each other's work to advance professional knowledge. A similar approach, they argued, could improve teaching by creating 'shared instructional products' to provide a consistent basis for evidence on the large scale. In the related field of 'learning design' (Dalziel, 2016) the shared instructional products would be 'pedagogical patterns' – rather like lesson plans, but bringing the pedagogic design to the fore. By sharing, testing and building on each other's learning designs, teachers become professional designers, and teaching becomes a design science - it keeps "improving its practice, in a principled way, building on the work of others" (Laurillard, 2012).

Seen as a design science, teaching can harness the inquiry that goes on every day in educational institutions and channel it into shared knowledge that could benefit the community of teachers. This is the thinking behind the new approach to teacher professional development now under way.

Teacher Collaborative Inquiry

Teacher professional development has increasingly been seen through a socio-constructivist lens that shifts the focus from *what can be done for teachers* to *what teachers can do for themselves* (for example, Makri, Papanikolaou, Tsakiri, & Karkanis, 2013; Najafi & Clarke,

2008; Schnellert, Butler, & Higginson, 2008; Van Driel & Berry, 2012). This research shows that

> "teachers' learning is facilitated and sustained in communities that are collaborative endeavors, acknowledge and value participants with different levels of expertise, and focus on practice-related issues" (Najafi & Clarke, 2008, p. 244).

To go beyond local endeavors to the community as a whole, Hiebert and Morris propose an approach to improving teachers' methods of teaching by creating and sharing artifacts or instructional products (Hiebert & Morris, 2012; Morris and Hiebert 2011). Such an approach enables understanding to be accumulated over time. Teachers and researchers create materials, try them out, and "feed the information from the trials back into the products" (Hiebert & Morris, 2012, p. 94).

This iterative process of collaborative sharing of scholarship-informed practitioner knowledge could be the key to reconfiguring teaching as a design science, because it addresses the challenge of teacher-led inquiry (Laurillard, 2012). It helps teachers build their knowledge of teaching by encouraging them to engage in the production and continual improvement of ideas of value to the community (Hong, Scardamalia, Messina, & Teo, 2009). Teachers work in "design mode" (Hong et al., 2009) with a collective goal of innovation and knowledge advancement (Scardamalia & Bereiter, 2010).

Teachers are not so much scientists – who try to understand how the world works. They are more like engineers – who try to make the world a better place. Like engineers, they use science, where it improves what they do. And like engineers, they use feedback, redesigning their teaching in the light of what happens in practice. 'Design scientists' – the term suits what teachers actually do.

A recent report on ten years of research on the professional development of teachers emphasised the importance of understanding the collaborative sharing of practice in teacher networks, and identified the importance of tools, especially digital tools, to support professional learning (Avalos, 2011). Others proposed 'knowledge sharing' as a way to transform educational institutions into 'learning organisations' (Argyris, 1994; Buckley et al., 2004). *Collaborative teacher inquiry* is an important change in professional development because it enables the teachers to move progressively from their teacher-centered thinking towards more student-centered actions that incorporate inquiry (Butler & Schnellert, 2012; Chang, Wu, & Wu, 2015).

Teacher collaborative inquiry was recently advocated as policy for the profession in the US (USDoE, 2014). But it also needs the tools to support this kind of professional learning. Unlike engineers, teachers have few tools to support their design work.

Learning Design

The learning design approach to planning teaching and learning activities enacts the collaborative inquiry that enables teachers to make their intuitive processes both visible and shareable (Ghislandi and Raffaghelli 2015), and to be more learner-centred (Dobozy, 2013). Over the last ten years the development of digital tools to support teachers' use of effective pedagogy has been driven by the need to represent learning designs as digital models, because this makes it feasible for teachers to share good pedagogical practice (Masterman, Walker, & Bower, 2013). The digital representation of learning design scaffolds the design of

high quality learning activities and reduces the investment of design time (Agostinho, 2006), because the design work is shared across the community.

However, these representational tools have not yet been widely deployed in the educational mainstream (Masterman et al., 2013). So while digital tools for learning design have become more sophisticated, allowing teachers to discuss, redesign and reuse learning designs on the small scale, it is not yet clear how easily they can be adopted into the widespread daily practice of teaching and learning (Ghislandi and Raffaghelli 2015).

Online Teacher Communities

The potential for online technologies to support the development of larger communities of practice has prompted researchers to examine what they could do for teacher professional development (Lin, Lin, & Huang, 2008; Matzat, 2013; Zhang, 2009), although they argue that the area is seriously under-researched (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009; Schlager, Farooq, Fusco, Schank, & Dwyer, 2009). Nonetheless, the evidence is slowly accruing that teachers value online communities for the exchange of ideas and links to resources (Rolando et al, 2014; Duncan-Howell, 2010), and find it encourages a more student-centred approach, and the use of digital technology (Archambault, Wetzel, Foulger, & Williams, 2010; Vavasseur & MacGregor, 2008).

The gradual shift towards the ideal of a widespread community for teacher collaborative inquiry is now transformed by the availability of massive open online courses (MOOCs). The pedagogic form of such courses is generally highly didactic for very diverse participants, but the platforms do also support discussion. Teacher development courses are more collaborative in nature, and can achieve the significantly higher engagement of 30-40% of participants, in comparison with the modest 2-3% of most such courses (Laurillard, 2016).

For the first time, therefore, there is a congruence between the digital tools to support the sharing of pedagogies, the digital platforms to orchestrate collaboration on the large scale, and the ambition for teachers to be able to engage in collaborative inquiry. For the first time, teaching is viable as a design science.

B. Why should leaders consider using this for implementing IT in schools?

Implementing IT in schools typically begins with implementing the hardware and software, and with good intentions to support teachers in using it. However, the good intentions fade fast. A recent UNESCO review of IT in primary education showed that national policies feature insufficient teacher development, because the distribution of funding resource between human capacity and technical capacity always favours the latter (Kalaš et al., 2012). This makes no sense. Teachers play the principal role in changing how effectively learners learn, and they need good solid support if they are to succeed in the difficult task of harnessing technology.

The argument for using the idea of teaching as a design science goes like this:

- Schools must adapt continually to their changing environment
- Schools must innovate to keep pace with the requirements of their context

- Rapid technology change means that teachers must use collaborative inquiry to manage the workload required for pedagogic innovation.

Who else is there to work out what the new pedagogies might be, and how to make optimal use of continual digital innovations? Who is better placed to discover what works? How can teachers be seen as anything other than a professional community of designers who build on each other's best ideas to make progress in the face of continual change?

Schools must adapt to a changing environment

School leaders are aware that their school - the curriculum and its teaching - has to develop in response to the changes in the very complex social-cultural-political-economic-technological-financial environment it inhabits. All these forces create pressures and constraints, against which the school leaders are trying to construct a forward-moving vision for their school and their students. Continual responsive development is necessary, but rarely funded.

Schools must innovate

Innovation moves forward when there is the opportunity for professionals to collaborate, exchange ideas, experiment, and share the results. This is the model we are familiar with in the world of scholarship and research, as well as in many fields in which professionals have to adapt fast to changing contexts, such as architecture, engineering, policymaking and IT design. The organisation of schools, the configuration of classrooms, the curriculum, and pedagogies have all undergone change and development in recent decades, but despite the increasing focus of national policies on the use of IT in schools, it is not being used to support the most powerful forms of learning (Ertmer & O'ttenbreit-Leftwich, 2010). To do this it is essential that teachers:

- are involved in the change and development process,

- have the opportunity to develop their own beliefs and sense of self efficacy with IT,

- have strong support from professional development and from the management and culture of their school (ALT, 2014; Ertmer & O'ttenbreit-Leftwich, 2010).

Governments have made little provision for such activities, and the responsibility for this quite dramatic shift in school practice has been left to the schools themselves in most countries. International surveys show that digital technologies have not yet been fully integrated in teaching and learning (OECD, 2016).

Teachers must collaborate to innovate

Innovation is costly, and inevitably increases workload in the short term, even if there is a planned pay-off in the longer term. It is especially difficult for schools to innovate when both policy and technology change at alarming rates. IT can be highly effective but it takes time to learn how best to use it, and embed it in the curriculum.

Collaboration spreads the cost of innovation. It also accelerates successful innovation, as each individual builds on the work of others, and contributes to building community knowledge. This is the model for science and scholarship, orchestrated through peer-reviewed academic journals and conferences. Teachers must be innovators now. So teachers need their own tools and support mechanisms to do the collaborative knowledge

building that will accelerate and distribute the responsive innovation schools need, as the next section shows. This is what it means to treat teaching as a design science.

C. How might school leaders incorporate the idea into their leadership practices?

Academic studies repeatedly demonstrate the need for teacher self-efficacy in IT and more teacher development, but school leaders receive little support for making this a normal part of the school workload. However, given the now near-ubiquitous presence of IT communications systems and design tools, there are more ways of lowering the threshold of innovation. This section suggests how IT can support not just students in collaborative learning, but teachers as well.

One approach is to use the *Learning Designer*, a tool for teachers that mirrors the academic journal process, by enabling teachers to build on what has gone before, experiment, innovate, test, redesign, test, publish. It can work well as a useful adjunct to meetings and discussions.

A related approach is for staff to do a relevant massive open online course (MOOC) together, as a way of keeping up-to-date with developments in blending digital learning with conventional class and homework activities.

A tool to support learning design

The Learning Designer is a digital tool that supports a pedagogical knowledge-building community by creating a constructionist learning environment for teacher development (Laurillard et al., 2013)[1]. As 'teacher-designers' (Goodyear & Yang, 2009), they can use a knowledge-building process, building on the work of others in the community, developing and testing their own innovative ideas, and then sharing the results with the community (Ferrell & Kelly, 2006; Laurillard & Masterman, 2009). Being online, the community has the capacity to reach all teachers wherever they are.

The pedagogy underlying the tool promotes the appropriate inclusion of the six types of learning operationalised by the Conversational Framework (Laurillard, 2012; Laurillard et al., 2013), giving them feedback on their design. As they plan the sequence and duration, and for each activity select the appropriate learning type, a pie-chart displays a graphic of the current balance of their pedagogy across learning through acquisition, inquiry, practice, discussion, collaboration, and production. In this way it prompts the teacher to articulate an optimal learning design, i.e. a sequence of teaching-learning activities for a specified learning outcome. Their design then becomes a digital object which can be shared with other teachers, adapted to other's contexts (Zhang & Laurillard, 2015), and exported as a Word document, or a plan for implementation in a virtual learning environment.

An online collaborative teacher development community

For scaling up the collaborative inquiry process, MOOCs now offer the kind of platform that succeeds in engaging teachers in discovering and experimenting with new forms of learning, such as blended learning – mixing IT solutions with conventional teaching, both in class and

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[1] The tool is open and free to all on simple registration at http://learningdesigner.org

at home[2]. For example, there are two courses on Blended Learning Essentials: Getting Started, and Embedding Practice. Teachers in schools and colleges have been following them together, as a school-based group, for example, so they can discuss the ideas as they apply to their own context.

The Learning Designer is used in both courses, as well as in MOOCs run by other platforms, where it has been embedded as a form of collaborative exercise for the participating teachers. The evaluations so far show that teachers are excited by the tool, and willing to share their ideas, and to adapt others' patterns to their own context.

Leadership practice

What can the school leader do? It is most important to demonstrate the value the school leadership puts on teacher professional development, on innovation, and finding out how to make optimal use of digital learning. Teachers are very good at helping themselves, and are happy to run the whole process, once it is endorsed by the leadership team. Here is one way to approach it:

1. Propose a collective focus on blended learning, or digital learning as a way of tackling a challenge of interest to the teachers, such as student motivation, class behaviour, difficult concepts and skills. It should be an issue of interest to the teachers where pedagogic innovation could have an impact.

2. Decide which MOOC(s) to look at and when (search for 'ICT blended digital learning' through Coursera[3] and FutureLearn courses[4]), to fit with the plan.

3. Plan a sequence of collaborative workshops over a term, each around an hour or so. The series of workshops could go through the following sequence of activities:

    a. Identify the good challenge(s) to work on and describe what you hope to achieve through a new pedagogical approach, and the groups who will work together to do this.

    b. Use a session to explore the Learning Designer tool: sign up, go to the Browser screen and explore the Education designs, click on one and review it in the Designer screen; experiment with changing the duration of some activities to see how the pie chart changes; click on Turn editing on, and edit the design by changing the text, adding/deleting activities within a segment, and teaching-learning activities (TLAs), changing times, learning types, etc, save and export as a Word doc, or as the code for others to use.

    c. Explore other designs to see how they use digital resources, and look at some of the reviews as well.

    d. Use the ideas from the MOOCs to plan a session that defines the learning outcome you want to achieve, and uses blended learning, where you add a resource to define the url students will use, and plan the activity around how they will use it.

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[2] A MOOC on *Blended Learning Essentials*, for teachers, runs on the FutureLearn platform: http://bit.ly/28RNQpI and http://bit.ly/2cV2Od9
[3] https://www.coursera.org/
[4] https://www.futurelearn.com

e. Exchange and peer review other groups' designs, and reflect on the feedback you give and receive to revise your design.

f. Test it out in class, and note what happens.

g. Discuss the results in the next workshop session.

4. Report back to a plenary staff session on where to go next on embedding digital learning as a way of addressing teaching-learning challenges, and how best to work collaboratively across the school to do this.

Such a programme of within-school innovation could build slowly, but would put the teachers in the driving seat of change.

Conclusion

Innovation is essential for schools to flourish in the face of unpredictable changes in political, financial and technological forces. Teachers are best placed to innovate, because they can understand and discover what their students need, what works, and how to mix the old with the new. But they have never had the support and trust of the education system that would enable them to develop the programme of teacher collaborative inquiry that could drive forward the effective innovation we need. By reconceptualising teaching as a design science, supported and orchestrated by the right digital tools, we could define a new vision for a teaching workforce able to innovate and adapt effectively.

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