Blended learning and e-learning support within the Cornerstone Maths Project -

A. Clark- Wilson, C. Hoyles

University College London, United Kingdom

1 Introduction

This paper describes the outcomes of a strand of research within the Cornerstone Maths project in England that has focused on teachers' participation in blended learning and e-learning support. Cornerstone Maths is a multi-year project that began in 2009 and adopts a design based research approach to scale the use of technology enhanced curriculum units on 'hard to teach' topics (linear functions, geometric similarity and algebraic patterns and expressions) within middle school mathematics (11-14 years). The project has developed from a set of pilots in the US and in England that have shown the efficacy of the curriculum units in a wide range of classroom contexts (Hoyles and Noss, 2013, Hegedus and Roschelle, 2013). A key element of the design of the 'at scale' professional development (PD) has been the blended approach that combines face-to-face meetings (in regional networks) with synchronous and asynchronous e-learning mediated by an online community and scheduled online webinars. We report findings from a cohort of secondary school mathematics teachers implementing the Cornerstone Maths unit on linear functions during the 2013-14 academic year.

2 Design principles

2.1 The curriculum units

Cornerstone Maths exploits the dynamic and visual nature of digital technology to stimulate mathematical thinking by:

- focusing on the 'big mathematical ideas' in middle schools mathematics (11-14 years);
- making links between key mathematical representations;
- embedding activities within realistic contexts;
- providing an environment for students to explore and solve problems within guided structured activities.

For example, the curriculum unit on linear functions focuses on the following mathematical ideas: coordinating algebraic, graphical, and tabular representations; y= mx+c as a model of constant velocity motion; the meaning of m and c in the motion context; velocity as speed with direction; and average velocity. The realistic context puts the students in the role of designers of games for mobile phones where they use mathematics to analyse and create simulated motion games.

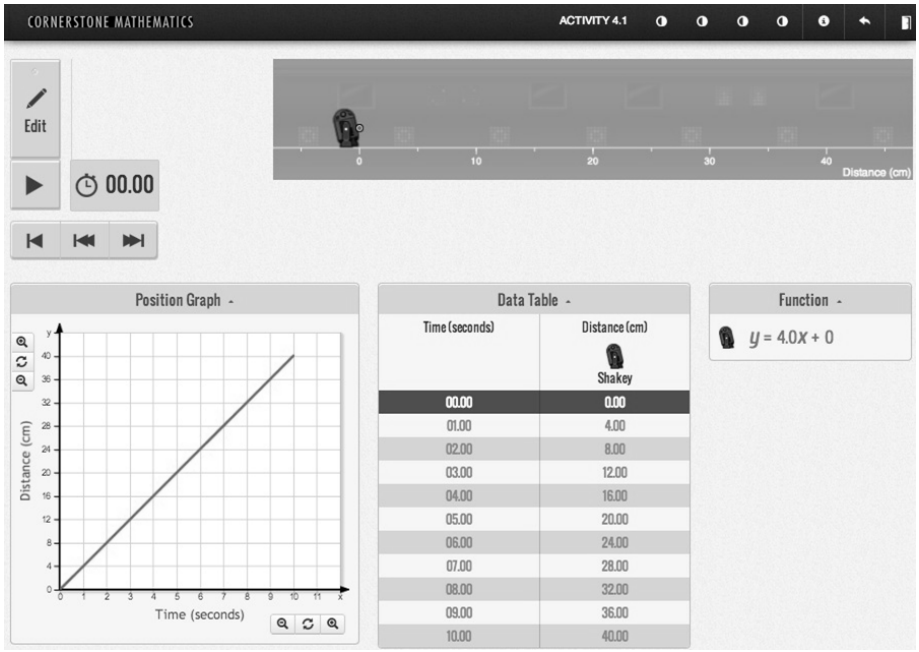

Figure 1: An activity from the Cornerstone Maths unit on Linear functions showing the dynamic linked representations

2.2 The research foundations

The Cornerstone Maths curriculum units emanated from earlier design based research projects that involved particular mathematical technologies (i.e. SimCalc, Migen eXpresser), the outcomes for which are reported elsewhere (See, Hoyles and Lagrange, 2009, Hegedus and Roschelle, 2013, Mavrikis et al., 2012). The process of making the essential design features of such resources available more widely to teachers involved a redesign whereby the software runs within a within a web-based browser. This bespoke software, alongside prescribed lesson activities and teachers' professional development form a curricular activity system (Vahey et al., 2013), which research findings have concluded to be most useful to support wider student access to technology in mathematics (Clark-Wilson et al., 2015, Hoyles et al., 2013).

Finally, in accordance with existing research, we acknowledge that transformative change in teaching practices takes time (Even and Loewenberg Ball, 2009), particularly when the dynamic mathematical technology is in the students' hands, as it challenges teachers to consider how the mathematics is different (changed representations, different modes of interactions etc.) and how their pedagogy might need to develop in response (Hoyles and Lagrange, 2009, Clark-Wilson et al., 2014).

2.3 The national context

In 2013 the UK Department of Education introduced a more aspirational national curriculum in which students meet some mathematical concepts earlier in their school experience (Department of Education, 2013). Alongside

this, successive national inspection reports document an underuse of computer software (alongside practical activities and resources),

'Carefully chosen practical activities and resources, including computer software, have two principal benefits: they aid conceptual understanding and make learning more interesting. Too few of the schools used these resources well.' (Office for Standards in Education, 2012, paragraph 62).

Alongside this, in England the political move towards increased school autonomy whereby schools decide on their own priorities and set their own budget can result in technology enhanced learning being just one of many priorities that a school might choose to address.

To date, there are 258 mathematics teachers from 124 schools across England who began to teach the CM curriculum unit on linear functions to a total of over 7000 students during the 2013-14 school year. They were organised within 6 Cornerstone Maths networks in partnership with an expanding group of PD 'multipliers'. However, within the context of an educational innovation such as CM, scaling cannot be interpreted solely on the basis of more schools and teachers. Other important quantifiable 'products' of scaling *for sustainability* include: an increase in professional networks; school-generated evidence of improved student attainment; an increase in the number of whole departments involved; wider use of materials (more classes within schools); and more teachers within departments involved. Alongside these products are the processes of scaling, which for CM included the development of: the web-based curricular activity system accessible on a range of technology platforms ; the teacher community; a localised PD offer (school clusters becoming networks); school devised evaluation approaches; a school based PD offer; localised schemes of work and the community of multipliers.

2.4 Design principles: the professional development

The CM professional development (PD) has been designed based on the following assumptions:

- teachers are not a homogenous group and 'one size' does not fit all;
- PD should be sustained over months and years – an initial one-day face-to-face event followed by synchronous and asynchronous events and ongoing online communication;
- teachers should adopt different roles within the PD process, i.e. 'teacher as learner', 'teacher as teacher', 'teacher as designer of learning', 'teacher as assessor/evaluator'.

The PD process is illustrated in Figure 2.

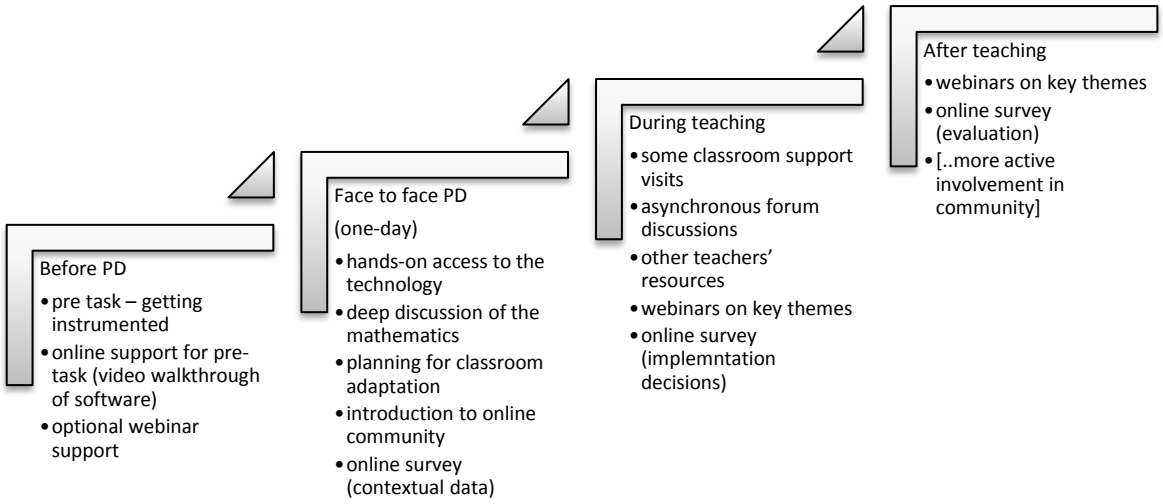

Figure 2: The complete PD process for each CM curriculum unit - from a teacher's perspective

The e-learning elements of the CM PD include: completing a pre-PD task (email and online); 'joining' the (online) project community; participating in the (online) project community; participating in project webinars; and responding to online project surveys.

Each of these elements is now described in more detail.

2.4.1 The pre-PD task

As the CM curriculum units of work use a bespoke software environment, the main objective of the pre-PD task was to offer the teachers an opportunity to become 'pre-instrumented' with the software in their own time and at their own pace. A task was sent to them two weeks before the face-to-face PD event, which required them to access the software and be introduced to its key functionality by adopting the role of a learner. Alongside this they were provided with access to short narrated video walkthroughs, which they could choose to watch, prior to (or after) attempting the tasks for themselves. During this same 2-week period, an optional webinar was organised by one of the CM PD team at which teachers could seek help, if needed.

2.4.2 The online CM Project community

The online CM project community was facilitated via the National Centre for Excellence in Teaching Mathematics (NCETM) web portal (Gouseti et al., 2011), which offers a private space for project teachers to: read, respond to and initiate discussion threads; and upload and download related digital files.

The teachers were introduced to this community during the initial face-to-face PD event in a workshop session where they had worked in groups to complete specific CM student tasks and were then asked to feedback on their experiences. The teachers were also shown where to download the electronic copies of the teacher and student materials for each curriculum unit and how they could upload any additional resources that they created to share with the CM project community.

2.4.3 The project webinars

The project webinars were organised to offer teachers an optional point of engagement with the CM PD team to coincide with when the teachers would be planning, teaching and evaluating the CM curriculum unit. The themes of these webinars were selected to respond to aspects of the classroom implementations that the teachers' had identified as being of interest to them. These included the teacher-led adaptation of the resources to support students who had English as an additional language (EAL) and the sharing of classroom-based strategies for the formative assessment of students' learning.

2.4.4 The online project surveys

The most important methodological tool to collect data on the teachers' classroom experience of the CM curriculum units 'at scale' was three online surveys, facilitated by Survey Monkey. As indicated in Figure 2, three surveys were administered to collect contextual data, implementation decisions and post-teaching evaluatory comments. These responses aligned with the evaluation framework for the complete project (Clark-Wilson et al., 2015) and sought to elicit: the teachers' choices of technological and classroom set-up; the chosen teaching and learning pathway through the curriculum unit; the teachers' overall evaluation of the materials; and the nature of their engagements with the project community.

3 Findings

3.1 Teachers' evaluations of the initial face-to-face PD event

All teachers participating in the CM project attend at least one face-to-face PD event, which they evaluate by questionnaire at the end of the day to gather their immediate perceptions of the effectiveness of the PD event and indicate the type of further PD support that they would value. The teachers were highly positive about the initial face-to-face PD and 88% of the cohort of teachers (n=195) judging it to be 'excellent' or 'good' in terms of preparing them to teach the CM curriculum unit in their classroom. Of the 166 teachers who offered suggestions for future PD support, 58% requested support on formative assessment and 57% on adapting the materials for Special Educational Needs

and for students with English as an Additional Language (EAL). Only 8% of the cohort specifically asked for this PD support to be mediated by webinars.

3.2 The online community

An individual teacher's participation within the CM project online community could extend to some or all of the following activities:

- making a first post to the forum within an existing discussion topic, which most teachers accomplished during the face-to-face PD event;
- accessing digital resources from the Documents area within the community;
- contributing resources by uploading them to the Documents area within the community;
- beginning a new forum thread.

Despite regular posts and uploads by the LKL Project Team, the CM online project community did not become the vibrant 'teacher-owned' online community as was originally hoped. The final project survey asked teachers about their activity within the online community *following* the initial PD event to which 57% of teachers reported that they had accessed it in relation to their teaching of Unit 1 (110 teachers responded to the survey). These 63 teachers described their use of the community as shown in Table 1.

Teachers' reported uses of the online project community	**% of teachers (n=63)**
To keep up to date with the project news	52%
To read questions or comments by the community	83%
To post questions or comments to the community	22%
To access the electronic version of the Teacher Guide	38%
To access the electronic version of the Student Workbook	37%
To upload resources for other teachers to access	3%
To download resources created by other teachers	11%

Table 1: Teachers' reported uses of the online project community

Very few teachers initiated discussion threads within the online community forum. However, as 83% of these teachers reported that they did read other people's questions or comments, this does suggest that the online community provided an important PD resource for those who chose to access it. The 49 teachers who did not report any use of the online project community cited their most common reasons as: insufficient time; forgetting that the community existed; not feeling the need to participate; and not encountering any problems. This does suggest that, as the use of such online communities is not yet established as part of most teachers' professional practice, we do need to work to change teachers' perceptions and experiences of such communities as a useful and valuable source of PD support.

3.3 Project webinars

Only 22 teachers (less than 10%) participated in at least one of the webinars that were convened by the PD Team to respond to teachers' requests for more support on adapting the CM curriculum unit for students with EAL and to discuss pedagogical approaches to support formative assessment. However the quality of both the teachers' presentation of their ideas and the discussions that ensued validated these webinars as a PD opportunity to be continued. When the remaining teachers were questioned about why they had not participated in the webinars, the most commonly cited reasons were that they were not at a convenient time of the day for the teacher, they were too early in the term and the teacher had not started teaching the unit yet or the teacher had never joined a webinar and did not know what to do.

4 Conclusions

Whilst the traditions of face-to-face PD support is well-established in the English mathematics teacher community, our findings suggest that most teachers are yet to have a substantial PD experience that involves blended and e-learning approaches. Consequently, a cultural shift is required within the wider teaching community such that alternative PD approaches become an accepted part of teachers' professional lives. Our findings suggest that, where teachers did engage fully in the e-learning and blended PD, they were overwhelmingly positive about its contribution to their overall experience. For the PD multipliers, the mediation of such e-learning and blended PD approaches is a non-trivial activity. For example, mediating an online webinar with multiple participants in different geographical locations requires a clear plan, which takes account of both the PD aims for the session, the anticipated participant experience and it should maximise the affordances of the technology that is being used to facilitate the online meeting. These aspects are beginning to emerge from the research into the impact of synchronous online learning (Cornelius and Gordon, 2013, Kear et al., 2012, Wang and Hsu), which will inform how webinars are designed for our future work with teachers.

5 Future research

The Cornerstone Maths research team are continuing to research the impact of the various blended learning approaches adopted within the different project communities and these findings will inform the development of a more comprehensive PD Toolkit – in collaboration with multipliers. Our next phase of work, a 2-year project that is being funded by the Nuffield Foundation, will enable us to conduct deeper research into the nature of teachers' development of mathematical knowledge in the Cornerstone Maths topic areas and their associated classroom practices with dynamic mathematical technologies.

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