Ellen Jameson, Lucy Rycroft-Smith, Rachael Horsman, Darren Macey, Tabitha Gould, Lynne McClure
Cambridge Mathematics, University of Cambridge

Liminal Design Practices Shaping the Cambridge Mathematics Framework

Learning from and contributing to an understanding of boundary objects in mathematics education

info@cambridgemaths.org @CambridgeMaths LinkedIn cambridgemaths.org

Design Challenge

Problem: Curriculum coherence in mathematics education is supported to varying degrees by different education systems. It is one factor involved in effectiveness and students' opportunity to learn mathematics.

- Cultural approaches: coordinating between perspectives and/or standardising to one perspective
- Cognitive approaches: the nature of mathematics and interdependence of ideas, the nature of learning processes in mathematics education

Background: Coordinating professional knowledge

Boundary Objects (Star and Griesemer, 1989; Star, 2015)

- Distributed professional problem-solving requires solutions which are acceptable within communities of practice (CoP) and also result in coherent action between CoPs (Lee, 2005)
- Boundary objects are "scientific objects which both inhabit several intersecting social worlds…and satisfy the informational requirements of each of them" (Star and Griesemer, 1989, p. 393).

Elaborations on and around the concept of boundary objects

- **Conscription devices:** boundary objects which "enlist group participation, are receptacles of created knowledge, and that are adjusted through group interaction" (Henderson, 1999, in Lee, 2005 p. 391). These might be used to prepare a design group to contribute to the formation of a boundary object (Lee, 2005).
- **Intermediary Objects:** boundary objects under development, in an intermediate stage in the process of negotiation and transformation (Boujut and Blanco, 2003, in Lee, 2005)
- **Boundary Negotiating Artifacts:** "artifacts and surrounding practices" used by designers to "iteratively coordinate perspectives" and to align "disparate communities of practice…to solve specific design problems" (Lee, 2005, p. 394-396); a potential stage in the development of a successful boundary object

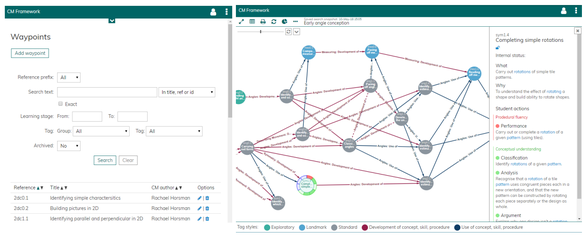
Design Goals

Support increased coherence by:

- Improving the ability for different communities of practice in mathematics education to coordinate
- Supporting multiple forms of professional knowledge in decision-making about curriculum content

The Cambridge Mathematics Framework

- A database of mathematical ideas and experiences, defined, referenced, and exemplified as actions and informed by research synthesis and consultation
- An interface providing a set of tools for searching and visualising mathematical content and the research base, and
- A guiding structure that determines what and how ideas are expressed in the database.

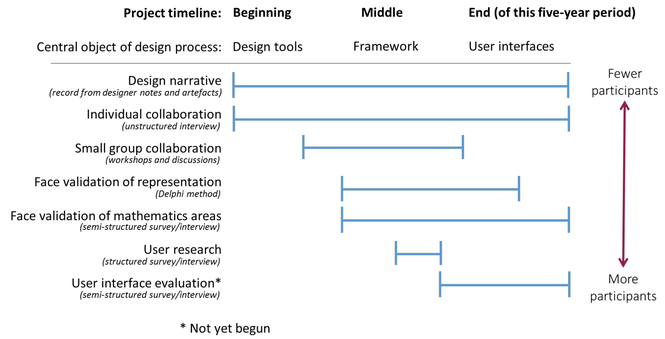


Potential users of the Framework

User category	Time Frame	Depth and Breadth of Use
Curriculum developer	Long; curriculum revision may occur in 5–10 year cycles	Breadth; may deal with aggregated information in the more detailed levels
Resource/textbook/ scheme of work developer	Medium; a few months to a few years depending on the resource	Breadth constrained to a portion of the curriculum, more detail but not the most detailed levels
Teacher	Short; a few days to a few weeks	Depth of content knowledge in targeted areas (but with occasional reference to horizon content knowledge)

Liminal design practices*

- **Negotiation** with team members, researchers, and potential users
- **Collaboration** on proof-of-concept projects that help to develop features of the Framework to support key uses
- **Evaluation** and feedback of work in progress so that we can refine and adapt our work according to what will be useful and used (Wenger, Trayner, and de Laat, 2011)



*For a more complete description of our design and research methods, please see https://www.cambridgemaths.org/

Preliminary outcomes: Delphi study

Evaluating the structure and theoretical foundations of the Framework

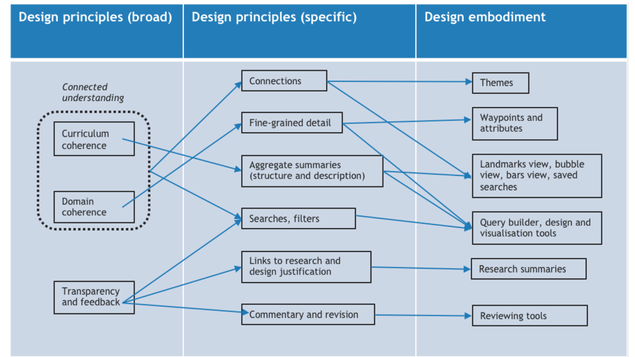
- Structured group survey method (Clayton, 1997)
- Mediated conversation among experts to find areas of agreement and disagreement
- Round 1 complete, Round 2 in progress
- Feedback on theoretical basis for design and the structure of the Framework
- So far, positive feedback on:
  - Approach to transparency
  - Application of theory to design
  - Usefulness of our focus on connections through waypoints* and themes*
  - The quality of the research summaries
  - The visualisation tools are on track to making the framework useful and accessible
- Round 2 will focus on points raised by the panel on connecting across topic areas and examining progression in big-picture mathematical thinking and doing

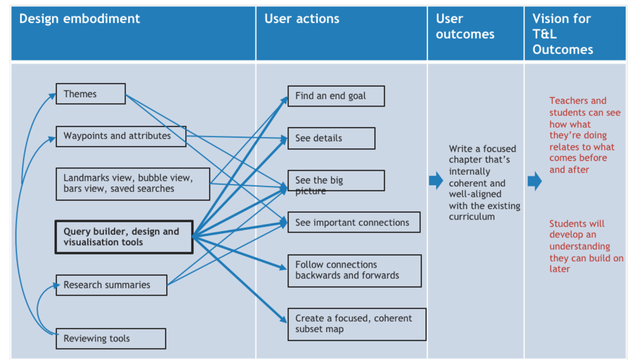
Delphi Round 1: Answers to Likert-scale items, n=16

	Frequency								
Question	**1**	**2**	**3**	**4**	**5**	**6**	**Median**	**IQR**	**Consensus (% in 2 adjacent)**
Q2: To what extent does understanding mathematics involve identifying and making use of connections?	0	0	0	2	12	2	5	0	Y (87.5%)
Q5: To what extent is the representation of connected understanding in the Framework consistent with your own sense of understanding in mathematics?	0	0	1	9	6	0	4	1	Y (93.75%)
Q10: How confident are you in the quality of the Framework based on the methods, goals, and design we have described so far?	0	0	0	6	10	0	5	1	Y (100%)
Q14: How confident would you be about publicly supporting the Framework?	0	1	2	4	9	0	5	1	Y (81.25%)

Preliminary outcomes: User scenarios

Textbook chapter writing example, mapping design principles to actions and outcomes





Discussion

- The Cambridge Mathematics Framework has many of the traits of a boundary negotiating artifact, and preliminary feedback suggests that there is potential for the Framework to be a functional boundary object.
- Next steps this year: Continuing evaluation as outlined in timeline, with feedback contributing to refinement of the Framework and the interface as it is received

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