CAMBRIDGE Mathematics

Background for the case study micro-report series

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Representing the work of

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As we reach points where the Cambridge Mathematics (CM) Framework is developed enough to use in practice, we conduct pilot implementations. We choose contexts which will allow us to trial key uses of the CM Framework, like resource authoring, curriculum design, and task alignment. In our case study micro-report series, we highlight individual contexts in which the CM Framework has been implemented and discuss the feedback we've received and implications for design.

The Cambridge Mathematics Framework is designed to be a common frame of reference for those involved in mathematics teaching and learning, principally in curriculum design, resource design, teaching and teacher education roles. More specifically, the CM Framework is a database of knowledge about mathematics teaching and learning which dynamically generates *knowledge maps*, visual representations of key ideas and relationships. The affordances and problems of knowledge maps as reference and learning tools have been generally characterised through studies of knowledge representation in education (Stahl, 2006) and knowledge management (Eppler, 2004). In general, good maps can address the questions *Where am I in the landscape, where can I get to from here, what route do I want to take, and what resources will I need for the journey?* Good *knowledge* maps also need to address the questions, *"how do I find relevant knowledge, how can I judge its quality, how can I make sense of its structure, and how do I go about applying it or developing it myself?"* (Eppler, 2004, p. 192). We have developed our design principles for the CM Framework by anticipating the answers to these questions as best we could, informed by research and collaboration. However, now that the CM Framework's structure and content are more developed, we can check our assumptions and inform our ongoing work by studying how the CM Framework is used in real educational design cases.

Positioning pilot cases within our evaluation plan

Pilot cases are an integral part of our formative evaluation plan[1]. In order for pilot case implementations to have a formative impact on design, they should occur after the necessary features and content are in place for someone to pilot their use, but before it is necessary to freeze the design for launch. These formative case studies presume that the necessary functionality and content are in place for some aspect of *utility* of the CM Framework (features affording participants the ability to meet their goals) to be evaluated. Their focus is therefore on utility rather than usability. This focus then informs the subsequent development of interfaces which are more tailored to particular groups of end users than the default CM Framework designer interface.

[1] Described further in Methodology: Formative evaluation (Jameson, 2019)

Affordances and problems of knowledge maps

Eppler (2004) highlighted four dimensions of the quality of knowledge maps: functional, cognitive, technical and aesthetic. In our current formative evaluation efforts, we focus on functional and cognitive quality. That is, we are looking at whether use of the CM Framework makes a valuable contribution to various areas of work in mathematics education, and whether its content and structure can be accessed and understood with a reasonable amount of effort, given the current state of the interface (Eppler, 2004). Our expectations for the utility of the CM Framework in educational design in mathematics – task design in this case – are broadly in line with the types of uses knowledge maps are typically designed to support. The affordances of knowledge maps, the things they enable their users to do, are described in Table 1. Each case study micro-report indicates which affordances are relevant for interpretation.

Table 1: Expected affordances of knowledge maps; those of particular relevance to the case being reported are indicated under 'This case.'

	Combined user groups	This case
Help designers to communicate ideas about knowledge to others; make tacit ideas explicit and present ideas in a form that users can relate to (Eppler, 2004; Vail, 1999)	✓	
Help users to "remember, comprehend, and relate knowledge domains through insightful visualization and aggregation of information" (Eppler, 2004, p. 200)	✓	
"[M]ake information actionable in new contexts, connect it with previous experiences" (Eppler, 2004, p. 189) – that is, professional learning and transfer	✓	
Help users to evaluate what knowledge is available for decision-making, and from what sources (Eppler, 2004)	✓	
Help users to see concepts within a bigger picture and to switch between multiple perspectives (Eppler, 2004)	✓	
Help users to evaluate and compare sets within knowledge domains – examining what knowledge is available, from what sources, and with what justification (Eppler, 2004)	✓	
Provide a "common framework" when searching for or contributing "relevant knowledge" (Eppler, 2004, p. 190), which itself supports professional learning	✓	
Contribute to the field by providing a big-picture perspective and a research base with respect to ideas that people in different roles may hold in common	✓	
Relate the big-picture perspective to different levels of underlying detail (Eppler, 2004)	✓	
Support professional learning in practical contexts: "just-in-time" (Vail, 1999, p. 23)	✓	

Likewise some of our concerns are broadly in line with the types of problems to which knowledge maps can be susceptible. From the perspective of the user, problems might include

- misunderstanding and/or misuse, including
  - "[f]ixation…of one frame of reference" based on one layout or set of data (Eppler, 2004; Neroni & Crilly, 2019), leading users to miss other insights,
  - oby-products of desired connections implying connections which are not meaningful
- people may stop using it if it isn't seen as being up-to-date or relevant,
- people may stop using it if they don't trust its structure or input (Durcikova & Gray, 2009), and
- people may stop using it if they experience information overload or if it takes a long time to get the information they are looking for (Eppler, 2004).

Potential problems for us as designers include

- tunnel vision arising from commitment to a particular structure or representation (Neroni & Crilly, 2019),
- difficulty of showing dynamic processes (in our case, how users will relate our more conceptual maps to students' learning over time in the classroom) (Eppler, 2004),
- providing for the commitment to keeping maps up-to-date according to substantive developments in the field, and
- progressive investment in the current state of the ontology makes later changes more difficult.

We are designing the CM Framework to enable the potential affordances of knowledge maps and avoid or mitigate the risk of problems which could interfere with their usefulness. Implementation of limited portions of the CM Framework in small real-world cases helps us to identify what to support or change in the design of the CM Framework in order to achieve this.

Guiding questions for formative case studies

We have considered the typical affordances and problems of knowledge maps, as well as our interest in context-specific uses, in developing a general set of guiding questions. Our planning and implementation of case study collaborations is guided by the following main questions:

1. How will participants use the CM Framework in the course of meeting their goals?
2. What contribution(s) will the CM Framework make?
3. What are the implications for the further development of tools and processes for working with the content of the CM Framework? For the content of the CM Framework itself? For the design principles underlying the CM Framework?
4. Are there assumptions we've made about the suitability of the CM Framework for particular uses which are specifically supported by the pilot? Specifically unsupported?

We then adjust these general questions to fit the context of each case.

Case study micro-report series

The results of these pilot case implementations inform our ongoing design discussions and our plans for further user interface development. We present the context and results of individual implementations as short papers in our series of case study micro-reports. We also present these studies at conferences in order to bring mathematics teaching, research and design communities into the discussion.

References

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