

# Probation Report Outline

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## Abstract

This is an “outline” of my probation report (due in September). It introduces the concept of dynamic maps, and gives some background on explaining why we would think about these things in the process of building a personal learning environment for mathematics.

“Outline” is in quotes because this document more represents the ideas I plan to put into some more standard outline format coming from the research school. If it lacks detail in places, that is because it will be expanded into a  $\approx 20$  page report!

## 1 INTRODUCTION

Mathematics, like many academic subjects, but more explicitly than most, is presented as a sequence of modules. Mastery, at any level, is evidenced by the solution of problems (cf. [5], page 157, referenced in [7]).

Behind this sequential presentation there is an implicit nonlinear arrangement of dependencies and cross-references. The idea of tracing this network has come up at various times in the history of mathematics. Matters of both *content* (definitions, theorems, proofs) and *process* (exposition, theory-creation, proof) have been taken up in these projects. For example, Leibniz's *characteristica* was focused on process, whereas contemporary visions of a world digital mathematics library are focused on content.

With various aspects of both types of projects now being realized on computers, the possibility of *dynamically mapping the relationships between mathematical process and mathematical content* is opened up. For example, we can realistically imagine charting how much mathematics a student knows at any given point in time by looking at a graphical overlay on top of a map of mathematical knowledge as a whole.

This vision is still just a technological possibility, not a fait accompli. Indeed, although various implementation steps pursuant to these goals seem clear (see Section 3), the practices adequate to achieve the most exciting results are rather less clear. In short, *the traction between ideas and implementation in a development context is not well understood, and we are led to consider the utility of dynamic maps in this area as well.*

I propose a multi-pronged approach to this concern, corresponding to the many-layered Deleuzian view described in DeLanda's “A New Philosophy of Society” [1]. Although it shares certain core elements, my project will go the other direction – from philosophy to new social arrangements and technologies.

This is why the “sensemaking steps” taken by this project (such as *Simplification, Interconnection, Mastery, Praxis, Linearization, and Experiment* – or *SIMPLE* for short) need to be “real”, not just “mental”.<sup>1</sup> In particular, a research project on dynamic maps should really be an applied project. (Discuss Popper’s “Conjectures and Refutations” here.) Sensemaking is not so much positivistic science as an embodied view on ingenuity.

To be concrete here: Our development goal is the production of a self-directed course of study in mathematics, extensible, editable, and self-documenting in the style of Emacs (or free software more generally), and no more difficult to learn. Attendant to such a development goal are some more “social” objectives, including that of motivating sufficiently broad participation. Participation is one way of evaluating success; of course, another key question for evaluation is: are users learning mathematics?

On this note and with reference to mathematics as a domain of study: even though we are talking about an applied social/software engineering project, the “meta-mathematical” mapping processes we will develop (outlined in the next section) in a certain sense have no aim of their own except for tracing the aims and behaviours surrounding mathematical practice. In this sense, the work is “anthropological”, and as a work of anthropology the project should be interesting and the findings applicable outside of mathematics.

To summarize the foregoing comments and points into one *pragmatic* question:

*Can various collaborating stakeholders, with nexuses at KMi, KWARC, and PlanetMath, guided by an anthropological method rooted in sense-making, develop, over the next few years, a self-directed course of study in mathematics, built using free software principles, with a significant and documented social importance?*

This, in turn, points to a simple enough *research* question:

*How does the dynamic map concept described in this document impact on this development process?*

My sense is that the pragmatic goal sketched above is simply impossible without rather sophisticated dynamic maps. Although this is not conclusive, I would point to the fact that nothing like “a self-directed course of study in mathematics, built using free software principles” has come into existence to date (despite it’s rather obvious attractiveness e.g. to various people working at the intersection of free software and mathematics) as evidence of the need for some additional sensemaking and coordination.

Adding to this that various missing ingredients (e.g. human resources, money, connections to other projects) have been identified in the course of PlanetMath’s existing 10 year “pilot” run – without anyone yet figuring out what to *do* about these gaps – again points more specifically to the sort of critical element likely to be useful here. Obviously, to track the importance of dynamic maps themselves as opposed to their constituent elements, we need to rule out the idea that simply throwing human resources, money, and connections at a project like PlanetMath is somehow “enough”. The only sensible way to do this seems to be to work comparatively, that is, to look at

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<sup>1</sup>Originally *Simplification, Interconnection, Control, Praxis, Motivation, and Experiment*, but *SICPME* isn’t a very cool acronym. In any case, the ideas,  $-$ ,  $+$ ,  $/$ ,  $*$ ,  $\partial$ , and  $\int$ , are the same. Note that whatever the acronym, it would be useful to compare Pólya’s problem-solving stages.

the sensemaking practices (or their absence) in other related efforts, either contemporary or historical. Indeed, the primary set of comparisons can be drawn between the “learning” and “development” strands of the project.

## 2 BACKGROUND

Actions going according to plan and plans suited to the desired actions. Sound too good to be true? Certainly this idea brings some additional questions come to mind.

How do we manage a large-scale project, given that its “success” depends on diverse contributions, skills, and motivations? What actually happens is often determined by purely formal thinking (“if you build it they will come”) and other similar illusions!

How much coordination is even desirable? Perhaps we want a very loose sort of coordination, like a common language that constrains what everyone can speak, but which permits the formation of an infinite number of sentences.

On this view, mapping the possible as well as effectuated activities becomes a sort of linguistic trace. The key thing is that as actions change, the language changes too. Out of this comes the idea of a dynamic map. (Cf. Korzybski [6] for related work.)

Such maps can be applied to development projects (language change) or to learning projects (language acquisition). The map can even be applied to itself. Thinking about things this way, it appears that a great many human artifacts and behaviors already “count” as dynamic maps. This research project is thus less a description of a new technology, and more a tracing of the shape of many existing technologies.

Still, we must ask some questions that are not yet thoroughly understood. How does embodied communication work relative to text? (Cf. “Language and gesture” [8].) How does it sometimes fail to work? What criticisms of communication or “communicationist” thinking are most appropriate? (Cf. Nishida [9].) What can we do, as critics or engineers of e.g. learning and teaching practices and processes? (Cf. Foucault [5].) Does the very specific idea of “knowledge management with sensemaking” provide a critical apparatus that will give us some mileage in applications? (Cf. Deleuze [2].)

These issues help contextualize the research question proposed above, and show how it connects to broader issues in project management, communication, and critical philosophy. In the two following sections, I sketch a design and implementation project that aims to answer the question (in the affirmative, or else say in a reasonable way why no affirmative answer was possible.) Throughout, my approach will be based on an iterative application, reevaluation, and extension of my proposed framework for sensemaking.

## 3 PROPOSED WORK 1: A PLE FOR MATHEMATICS

The first phase of the implementation-for-mathematics project can be sketched easily enough. We want: a (1) personalized, (2) semantically adaptive, (3) social platform, (4) for learning, (5) and doing mathematics:

- (1) We can use and existing registration and login features of PlanetMath, and extend them with more personalizable services.
- (2) We can connect PlanetMath to the OMDoc/TNTBase/sTeX/JOBAD toolset developed at KWARC.

- (3) We can improve PlanetMath's forums, add blogging and blog-aggregation features, and play well with things like GNU Social.
- (4) We can add STACK and/or EduTeX for interactive problem solving.
- (5) and we can integrate wherever possible with the ArXiv, e.g. by adding links in both directions.

Since this is just a matter of polishing up and integrating existing tools, it shouldn't be too hard. What's interesting about this is to ask how close these somewhat obvious steps bring us to the dynamic mapping ideas. Certainly they do not get us all the way there: the question then becomes, what's next?

Answering that question will be related to solving motivation and incentive problems. (Cf. TopCoder<sup>2</sup>, calc101.com<sup>3</sup>.) This means listening to any complaints or noting any obvious gaps, doing sensemaking and subsequent implementation work around these things.

Any data or stats we can get out of the system will be helpful. (E.g. to sketch coverage, or coverage versus usage, etc.) Indeed, to implement the "PLE idea", we will often want to make such data available to learners, so that they can use it to design and self-regulate their own learning practices. This, in turn, should create a crowdsourcing component.

The question about contribution of exercises and high-quality semantic mathematics will be challenging. Redesigning PlanetMath's scoring mechanism to take this sort of "quality" into account may help. Working to get various faculty-level contributors appropriate forms of "credit" for their participation will also help. (I have at least one collaboration of this nature in mind.)

## 4 PROPOSED WORK 2: DEVELOPING THE DYNAMIC MAP CONCEPT

- First of all, returning to Deleuze as a "philosopher of record", I would suggest that the concept of the *fold* (cf. [3], [4]) is a multi-layered idea that is similar to my idea of a dynamic map, expressing both (1) a candidate definition for subjectivity; and (2) the mathematically straightforward idea of a map from a surface to itself. Although the conceptual distance is small, I will be specifically examining *implementations* of this idea, and delving into the concerns appertaining to "implementating Deleuze" more generally.
- Lots of tools exist for project management and dynamic mapping thereof. (E.g. Trac, github issues, etc.) Some background research on how these tools are used/useful will be in order.
- PlanetMath itself implements a basic "issue tracker" in the form of *corrections*. In what ways is this useful or not useful, working or not working? What other workflows exist for dealing with crowdsourcing and/or education that we could try out? (E.g. editorial boards work in an "academic" context, but do they work for education? How might things like Peer 2 Peer University<sup>4</sup> or ideas from various Popular Education programmes work here?)

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<sup>2</sup><http://www.topcoder.com/>

<sup>3</sup><http://calc101.com/>

<sup>4</sup><http://p2pu.org/>

- PlanetMath has historically had a slow response time when it comes to feature requests. Why is that, and what can we do about it?
- The SWOT/SECI/SIMPLE models are supposed to work for project management – but can they be retuned to work for much, much, bigger things like managing an entire academic discipline – or something like “science”? Getting some sense of the flows involved certainly wouldn’t hurt as “background research” (e.g. getting info about the number of STEM graduates, the demand for them, and other stuff like that).
- Looking at this the other way, although PlanetMath and its immediate context is useful as a “main example”, other *small* examples will make for a much better research project. Luckily there are many free software and content projects out there (and the author is already involved with a few of these, including Etherpad<sup>5</sup>). This will be useful for purposes of comparison.

In short, to make this work well, there should be both an “HCI” component, related to tools people use to keep track of things and processes, and a more general socio-cultural component, relating to broader issues surrounding the use and development of these tools.

## 5 CONCLUSION

I have sketched a Ph. D. project about supporting the learning and practice of mathematics in a contemporary online context. The challenges faced by any such project are both social and technical, and in a large-scale project, particularly complex. In order to deal with this complexity I have introduced a set of SIMPLE and widely applicable sensemaking steps, which, combined with the idea of dynamically mapping various forms of social engagement, forms the basis of an anthropological method suited to working with this kind of complexity.

I’ve shown how this work connects to the ways in which project management, communication, and critical philosophy tackle *learning* and *collaborative development work*. The key outcomes of my proposed work are (1) a semantically adaptive, socially networked, personalized learning environment for mathematics, and (2) a strategy for effectively managing “crowdsourced” development projects.

## Bibliography

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<sup>5</sup><http://github.com/ether/pad>

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