# PlanetMath/Planetary

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**Abstract.** This paper presents our work in progress on the Planetary system, along with a critical evaluation of the project relative to its stated goals and the goals of one of its main "clients", PlanetMath.org.

**Keywords:** mathematics, learning environments, encyclopedias, Drupal

## 1 Introduction

The metaphor or analogy implied by the title of this paper is that PlanetMath[3] is like an operating system for mathematics, and Planetary[4] is like a kernel for this system (think GNU/Linux). This analogy is both apt and sloppy.

In particular, PlanetMath is not a complete mathematics "userland". Indeed, it is best known for its mathematics *encyclopedia* which contains over 9000 entries, and defines around 16000 concepts (see [1]). Another key feature of PlanetMath is that every entry is *discussable* via its own attached, threaded, forum. PlanetMath has a variety of other features (like mathematics rendering, a term autolinker, and a workflow and authority model suitable to distributed encyclopedia authoring), most of which were developed in a custom system based on Perl and XSLT (called "Noösphere"), which was written up in Aaron Krowne's 2003 Master's thesis [2]. While this feature set has provided a (mostly) stable and functional basis for a popular community mathematics website for over a decade, the custom nature of the software made extensions and adaptations relatively scarce.

In 2010, the present first author was beginning a Ph. D. project on "Semantic Adaptivity and Social Networking in Personal Learning Environments" that aimed to extend PlanetMath so that encyclopedia entries were "connected to exercises and applications, preliminary materials, and resources for further learning", and to develop software that would track individual performance and provide personalized advice based on aggregated data.

Due to the extensive (and intensive) nature of software modifications that would be required to do this well, he welcomed the possibility to collaborate with Michael Kohlhase and his team at KWARC[5] on a complete re-build of Noösphere, using contemporary web frameworks, and integrating the "KWARC

[3] PlanetMath.org (2001-ongoing), http://planetmath.org
[4] The Planetary System (2010-ongoing), http://trac.mathweb.org/planetary
[5] http://kwarc.info

stack" of semantic technologies into PlanetMath. This led to an early prototype of the Planetary system being named a finalist in Elsevier's Executable Papers Challenge [3], but it was not until this year that an end to the PlanetMath rebuild appeared to be within sight.

The rest of this paper will descibe our technical achievements to date, discuss the immediate road ahead, and reflect on Planetary's potential, particularly from the point of view of its use on PlanetMath. (The reader is referred to [4] for a contemporary high-level overview of Planetary as a whole.)

## 2 A new "kernel" for math on the web

As indicated above, one of our main goals behind rebuilding PlanetMath's software was to be able to more easily bring new developers into the project. Another was to integrate new technologies.

After our first round of prototyping, Drupal 7 emerged as a good candidate solution for both of these issues. It is a popular system, with a wide variety of contributed modules – and it also supports a healthy marketplace for professional services. So far, the Planetary team has 14 contributors (most of them computer science students at Jacobs University, Bremen), with the current second author focusing on developing Drupal support for features and workflow similar to those found on PlanetMath.

We have found that there are some modules that can be installed and used directly, with minimal configuration (e.g. *privatemsg*, for the exchange of private messages between users) – others needed to be custom-built (e.g. support for *corrections*, essentially a custom form of bug report used to maintain accuracy and quality in PlanetMath's encyclopedia). Some others, like the *userpoints* module can be installed and used with minor tweaks. All in all, we depend on around 25 existing contributed modules, and have written a comparable number of custom modules. For a few legacy features, we took things in a new direction:

1. For mathematics rendering, we are using LaTeXML[6]. Full support for MathML lays the foundation for many other future services. (For example, our Executable Paper demo integrated JOBAD, a Javascript tool for interacting with mathematical documents while reading.)
2. In place of, or alongside, the legacy autolinking service, we have a new interactive ("semi-automated") autolinker, which should provide greater precision for links – and, again, open the door to a range of new interactive services during the document-authoring/editing process [5]. In addition, this feature is made possible by building on top of a real-time collaborative editor Etherpad, so we will get real-time collaboration on mathematics documents "for free".
3. For access to the encyclopedia by Mathematics Subject Classification (MSC), we used a new Linked Open Data (SKOS) implementation of the classification system [6]. This was motivating partly because it allowed us to develop

[6] http://dlmf.nist.gov/LaTeXML/

and demo an integration between Drupal, LaTeXML, and the Virtuoso triple store, which, again, will be useful in a range of future applications (e.g. we will be able to generate RDFa that can then be used to maintain backlinks, for example from an image to all of the articles that include that image).

There are some other features that have been developed for Planetary that are in use in other installation environments (namely, Michael Kohlhase's Computer Science courses), that are not yet integrated into our work on PlanetMath: specifically, an integration with SVN via TNTBase[7], which provides the ability to edit math on the web without ever opening a web browser, and a new books module, which provides support for lengthy documents. These features may eventually make their way into PlanetMath, but they can already serve to illustrate part of our goal in Planetary: to make a system that is useful in many different math-on-the-web contexts, with various features available in the various environments that need them.

One of our core aims in this regard is to make Planetary install "out of the box"; we are currently in the process of using Drupal's *profile* project to package up our work and support this. In future, this should be very helpful both for users and developers.

## 3 The road ahead

As we can seen in Figure 1, the latest version of Planetary captures many of the same interactions as the legacy version of the site, although the two sites are certainly not identical.

In the short months leading up to CICM in July, we aim to finalize the handful of features that remain unimplemented or partly implemented, and be ready to enter a "beta" with the new platform (i.e., ready to make it the software you see when you browse to PlanetMath.org). From a project management point of view, we have passed our last "milestone" and can now focus on feature-driven development. Our path to deployment on planetmath.org looks like this:

- May 4th: final module tweaking and building for features like requests, private messages, scoring, notices, and the object orphanage.
- May 11th: any final "alpha" features (e.g. finish integrating Etherpad), and a first round of optimizations.
- May 18th: A public "alpha" launch.
- June: Add any "beta" features that we need, in consultation with the PlanetMath user community.
- July: Final improvements readying the site for a switch over to the "beta".

[7] http://tntbase.org/

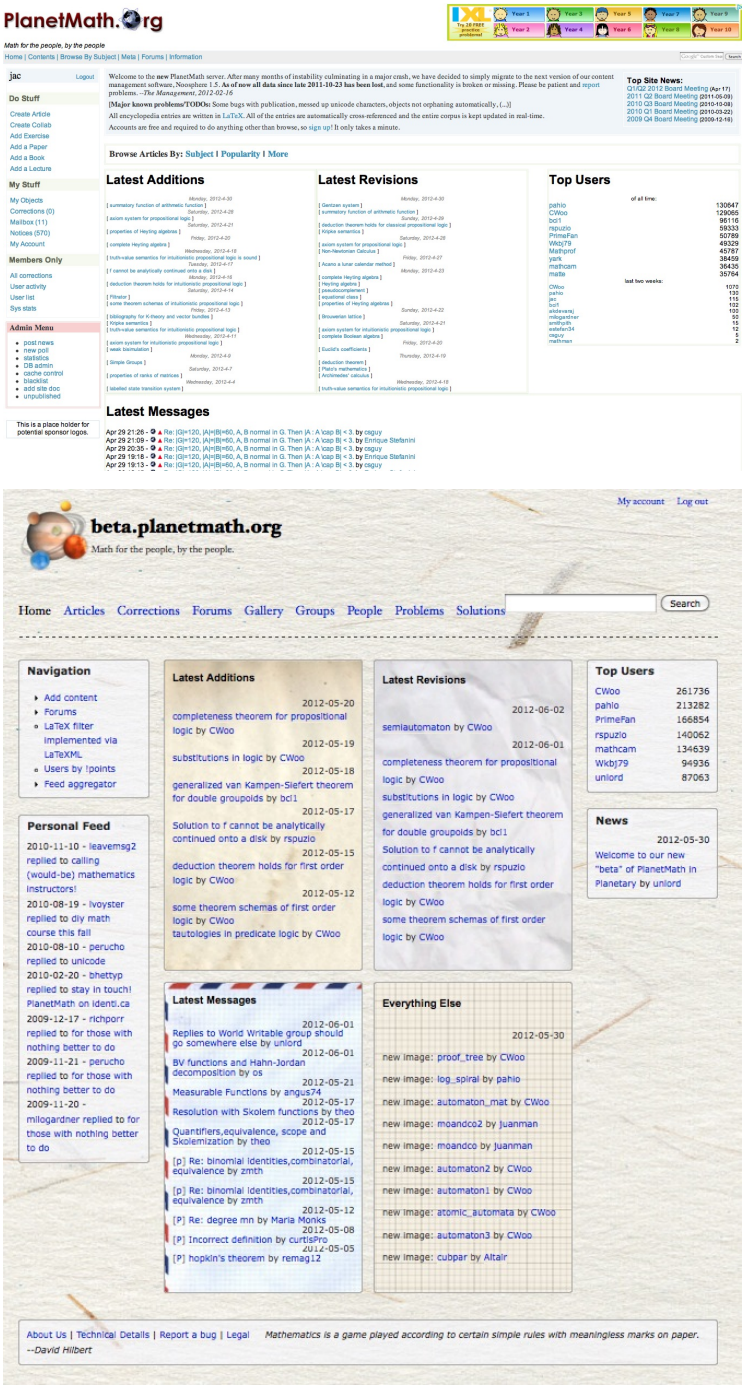


**Fig. 1.** The current PlanetMath webpage under Noösphere 1.5, and the new "beta" version.

## 4 A critical evaluation

The question we take up in this section is: is the Planetary system meeting the aims of its developers, and the needs of its user community? What could it do to improve?

Clearly, releasing the system on PlanetMath, and providing links the code[8] and installation instructions[9] should improve things dramatically. The new PlanetMath will render LaTeX blazingly fast, have better links, and a range of new features that address long-standing user concerns and also some nice surprises.

But our aspirations have in fact been much bigger – and switching to Planetary *should* play a big part in bringing them closer. Specifically:

- It is relatively easy to make new content types in Drupal, and we are introducing "problem" and "solution" node types, and allowing people to attach them to encyclopedia articles, and discuss problems with attached "questions" and solutions with attached "reviews".
- Our aim will be to develop some *semantically aware* activity tracking and "heads up" information for people using this system (see Figure 2). It is within reach to provide "related problems" using the MSC classification, but further analysis of theory dependencies (or approximations to the same) should allow us to give links to "simpler related problems", automating a key Pólya heuristic. Even without sophisticated tools, our hope is that a new generation of *students* will feel more encouraged to participate when problems and solutions become "first class" objects in the system.
- Our hypothesis is that the introduction of problems and solutions will provide a vital quality check, and enhancement. In short: encyclopedia articles that do not have attached exercises (or applications) should not necessarily be presumed to be useful. At the same time, exercises that do not have attached solutions may be too hard, i.e., the relevant subjects in the encyclopedia may not be sufficiently developed.

While we are *not there yet*, this is an example of the sort of thing we expect this technology together with the "encyclopedic approach", puts tantalizingly close to within reach.

[8] https://github.com/cdavid/drupal_planetary
[9] https://trac.mathweb.org/planetary/wiki/DrupalPorting

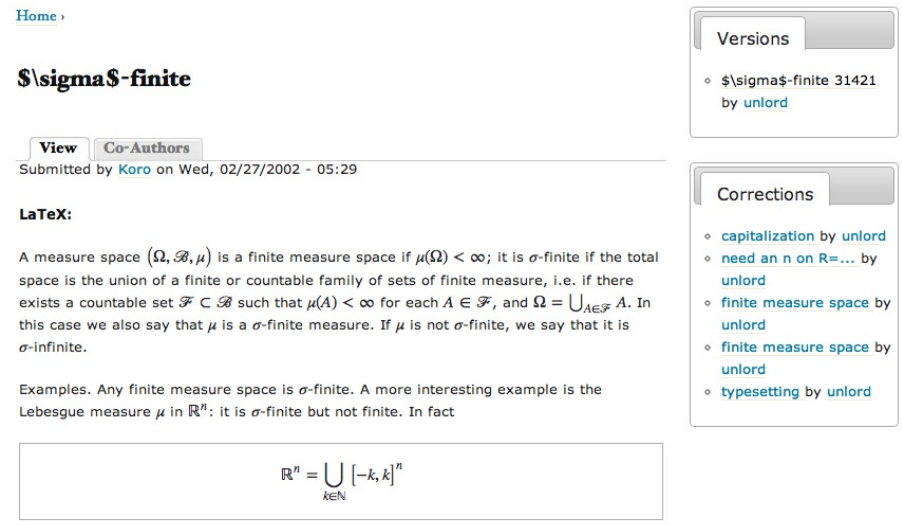


**Fig. 2.** Important information about articles (like outstanding corrections) in a "heads up" style display, shown here for a recent alpha version.

Note that PlanetMath, unlike, say, Wikipedia, is not *constrained* to be either "just a wiki" or "just an encyclopedia" – so, interactive problem sets and/or peer tutoring are welcome in PlanetMath, though they might not fit so cleanly within the existing Wikimedia family. Rather, the encyclopedic approach envisioned here connects interactions to a carefully curated and *systematic* knowledge base – in contrast with, for example, the StackExchange sites, at least in their current implementation.

In any event, the perspective developed above should brings up some big questions: in brief, what happens to mathematics teaching when students have access to a universal solutions manual for their mathematics course work? We may be able to *measure* whether lecture/homework/test is as effective for learning, as, say, participating in applied research projects.

Still, the hazard here would be to imagine that this can all happen overnight. It has taken PlanetMath 10 years to *define* 16000 terms, how much time will it take to provide a good *exposition* of those terms (always assuming that we do find users who want to participate in this process)?

Furthermore, as we have learned in the last few years, programming Drupal is not equally easy for everyone, documentation is not always clear (or available), and development work is generally a slow process (even with skilled programmers onboard). If the potentially revolutionizing changes (sketched above for mathematics education, but relevant also to research) of math on the web are

to be realized, most aspects of this project will have to scale up a lot – and hopefully coding will be less of a bottleneck.

## 5 Conclusion

We have described the Planetary system, and discussed its relevance to PlanetMath's continued project of building "a central repository for mathematical knowledge on the web, with a pedagogical slant." We expect the phase of work we will complete this summer to fully renovate and modernize PlanetMath. But once we have readied and deployed an extensible – and re-deployable – core, in a sense, our main work will just be beginning.

For example, we recall the meaning of "planet" from the blogosphere, i.e. planet-as-aggregator. Thinking in this way, PlanetMath might best fulfill its promise not *just* with a great new platform, but by successfully integrating content from other math on the web projects. This sort of aggregation service has yet to be realized, but forms a highly interesting direction for future work.

Indeed, if we are going to do anything about the "$500 million pricetag" for building a math-capable AI[10], we either have to bring about greater efficiencies, or spread the cost out over a relatively large number of people. Without making promises about just when this will be accomplished, we assert that we have, with PlanetMath and now Planetary, taken some vital steps in this direction.

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