# The PlanetMath Encyclopedia

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#### Abstract

The history of PlanetMath.org is discussed, tracing its inception, stabilization, and some defining challenges. Research and outreach efforts that have been conducted in the course of work on the PlanetMath project are reviewed, and the scope and reach of the resource are discussed. Recent developments are indicated briefly. Some remarks evaluating PlanetMath's trajectory and content conclude the paper.

**Keywords:** online communities, mathematics, collaboration, encyclopedias, Commons-Based Peer Production, PlanetMath

#### **1** Introduction

From PlanetMath.org's landing page<sup>1</sup>:

PlanetMath is a virtual community which aims to help make mathematical knowledge more accessible. PlanetMath's content is created collaboratively: the main feature is the mathematics encyclopedia with entries written and reviewed by members.

This short paper describes the history of the PlanetMath encyclopedia. The history of this resource cannot be easily separated from a history of the PlanetMath community and the technology behind the site, though the presentation here is not especially technical. The reader who is interested in a succinct overview of the *current* characteristics of the encyclopedia will find what they seek in Sections 6 (quantitative aspects) and 8 (qualitative aspects).

# 2 Beginnings

The early history of PlanetMath is wrapped up with that of the similarly-named website, MathWorld.<sup>2</sup>

Eric Weisstein began collecting the material now found in MathWorld as a high school student, and continued the project as a college student in the late 1980s. "Eric's Treasure Trove of Mathematics," went online in 1995, when Weisstein was a graduate student in astronomy at the California Institute of Technology.<sup>3</sup> In November 1998, Weisstein made a deal with the CRC Press to publish his encyclopedia in book format, as the *CRC Concise Encyclopedia of Mathematics*. One year later, Weisstein accepted the position of encyclopedist at Wolfram Research, Inc., and the renamed "MathWorld" site was unveiled in December 1999.<sup>4</sup> In March 2000, CRC Press sued Weisstein and Wolfram Research for copyright violation, forcing MathWorld off of the internet.<sup>5</sup>

<sup>&</sup>lt;sup>1</sup>http://planetmath.org

<sup>&</sup>lt;sup>2</sup>http://mathworld.wolfram.com

<sup>&</sup>lt;sup>3</sup>http://www.echarcha.com/forum/archive/index.php/t-19516.html a copy of the now-defunct http:// mathworld.wolfram.com/about/erics\_commentary.html

<sup>&</sup>lt;sup>4</sup>http://en.wikipedia.org/wiki/Eric\_W.\_Weisstein

<sup>&</sup>lt;sup>5</sup>57 U.S.P.Q.2d 1220 (C.D. Ill. 2000)

In the words of Eric Weisstein: "if you ever assemble a body of knowledge that you want to share with others, you don't want to go through what I have just gone through."<sup>6</sup> So it came to pass that in the Fall of 2000, Nathan Egge and Aaron Krowne, at that time both undergraduates at Virginia Tech, came up with the idea for PlanetMath: a collaboratively created mathematics reference work that would have resistance to copyright threats built in, in the form of an open content license. By the summer of 2001, the basic infrastructure for creating an encyclopedia was complete, and a fledgling community had grown up around the resource.

The CRC lawsuit was settled for an undisclosed sum in late 2001, and on November 6, 2001, Math-World returned to the internet.<sup>7</sup> But in the mean time, a new online community had been born – with some very different principles and practices. Whereas MathWorld's terms of use disallow archival copies, PlanetMath regularly publishes snapshots of the content for download. Moreover, users are permitted (and, indeed, encouraged) to copy, mirror, redistribute, print, remix, and reuse PlanetMath content for commercial or any other purpose – so long as all such works are published under the same license as PlanetMath, granting downstream users the same rights.

# **3** Stabilization

The key reference for PlanetMath is Aaron Krowne's 2003 Master's Thesis, written at Virginia Tech [6] under the supervision of Ed Fox. In this thesis, Krowne describes how the early design and development of the site benefited from continuous feedback in the #math IRC channel on Undernet.<sup>8</sup> He also details the key technical and community features of the site as they developed in this period:

- A state-of-the-art system for displaying mathematical notation on the web, starting from LATEX sources.
- A flexible authority model that can support both wiki-style articles (that anyone can edit), and a more academic style, where articles are owned by one person, who may, if they wish, grant co-authorship permissions to chosen others, and who must respond to separate commentary from peer reviewers (cf. [7]).
- A discussion forum attached to every encyclopedia article, which helps give the resource a "pedagogical slant".
- An autolinking service that helps integrate content into the site, by enabling authors to focus on the contents of one article at a time.
- Workflow built around corrections and watches, including a feature whereby articles are "orphaned" if a correction is not responded to after a given period of time.
- A scoring feature that provides a rough estimate of how much value each user has contributed to the site.

In 2003, PlanetMath incorporated, and in 2005, obtained non-profit status, so that it could accept taxdeductible donations (in the US). Together with a small stream of ad revenue, this has covered hosting and other maintenance costs.

<sup>&</sup>lt;sup>6</sup>See Footnote 3.

<sup>&</sup>lt;sup>7</sup>http://mathworld.wolfram.com/about/faq.html#history

<sup>&</sup>lt;sup>8</sup>irc://irc.undernet.org/math

#### **4 Pushing the limits**

In 2003, the present author was enrolled as a graduate student in mathematics at the University of Texas in Austin, and in possession of a large and growing personal collection of very tersely-written definitions and proofs relevant to the department's prelim exams.<sup>9</sup> In fact, this work had as much to do with the tradition of computer mathematics in the air in Austin (QED, Maxima, ACL2, AM) as it had to with exams. A representative example:

(lebesgue outer measure: fact: lebesgue outer measure is infimum of lebesgue outer measures of open supersets)
1: X ⊂ R<sup>n</sup>
2: L = {O © R<sup>n</sup> : O ⊃ X}
3: |X|<sub>e</sub> = inf<sub>O∈L</sub>({|O|<sub>e</sub>})

After discovering PlanetMath and striking up a correspondence with Krowne, one night we uploaded the contents of the "Austin Problems in Mathematics – Cross-Index" (styled APM- $\xi$ ) into the PlanetMath encyclopedia as world-editable "seed entries". This turned out to be a first-rate disaster.<sup>10</sup>

The primary complaints from community members were:

- (1) the entries could not be understood without reading an accompanying FAQ;
- (2) a casual visitor to the PlanetMath website might get the wrong impression about the nature of the encyclopedia when looking at "apmxi" entries; and,
- (3) nearly 600 entries had been introduced into PlanetMath by the site's administrator in one big batch, circumventing, at least in outward appearances, the site's usual model of careful review and collaborative editing of entries.

Subsequent to a poll, it was decided that the apmxi entries would be "orphaned", and any that were not adopted by community members after a week would be deleted from the encyclopedia. This was the fate that befell most.

The event was a defining moment in the history of PlanetMath. In the first place, it was a testament to the strength of the community's norms. Secondly, it showed that the specific affordances of computers, e.g. for mass processing of data, or for dealing with hypertextual complexity associated with alternate related treatments of a given topic, needed to be tempered to work well for the *people* involved. These issues would set much of the research and development agenda around PlanetMath for the following decade.

## 5 Research, outreach, and some critiques

In 2005, several established PlanetMath contributors met in person at a Symposium on *Free Culture and the Digital Library* at Emory University, where Krowne was then based. Contributed papers looked at

- an adaptation of PlanetMath's software for collaborative creation of course notes in a graduate course on ordinary differential equations [10];
- experiments with a novel hypertext system based on the idea that everything is annotatable [1]; and,

<sup>&</sup>lt;sup>9</sup>http://metameso.org/~joe/math/Xi.pdf

<sup>&</sup>lt;sup>10</sup>http://wiki.planetmath.org/cgi-bin/wiki.pl/one\_week\_in\_october

• the dynamic tension between the non-copyrightability of ideas, and the necessity of conveying ideas in copyrightable expressions, and the ramifications for mathematics [12].

These reflections on copyright (and copyleft) were subsequently expanded in an article for *First Monday*, which looked at the drawbacks of current copyleft licenses, particularly "license lock" [8].

We presented talks about PlanetMath in the *Math on the web pavilion* at two Joint Mathematics Meetings (San Antonio, 2006<sup>11</sup>; New Orleans, 2007<sup>12</sup>), and in a session on *The Role of Open Source Math Projects in the Mathematics Community* at MathFest (Madison, 2008)<sup>13</sup>; and at more specialized workshops: *The Evolution of Mathematical Communication in the Age of Digital Libraries* (Minneapolis, 2006)<sup>14</sup>, and *Mathematical Knowledge Management: Sustainability, Scalability and Interoperability* (Halifax, 2007)<sup>15</sup>.

We also made efforts to create a print version of the PlanetMath encyclopedia (retitled the "Free Encyclopedia of Mathematics"). The 2004 attempt, in two volumes<sup>16</sup>, and a 2005 attempt in one much nicer-looking volume<sup>17</sup>, thanks to Ross Moore's contribution of multinclude.sty and other tweaks.<sup>18</sup> Still, the resulting 1971 page PDF was more a proof of concept than a printer's proof.

On the development side, PlanetMath was thrice supported by Google's Summer of Code (2006–2008). The best outcome of this was that PlanetMath's autolinking subsystem was turned into a modular piece of code, NNexus<sup>19</sup>, as written up in [5]. PlanetMath's software improved further under contract with Springer, pursuant to the creation of StatProb.com.<sup>20</sup> PlanetMath's sister site PlanetPhysics.org<sup>21</sup> is currently in the process of switching over to this platform, termed Noosphere 1.5.

However, the development effort wasn't particularly able to keep pace with the feature requests generated by the user community.<sup>22</sup> Nor did the Noosphere codebase present a particularly compelling resource for capable computer mathematics developers like Claus Zinn [14] and Christoph Lange [9], to jump into and improve. Zinn wrote:

The rapid growth of math resources on the web, which is further pushed by wiki-based communities, is both a threat and an opportunity for intelligent math learning environments [...] If we could harness the collaborative authoring process and encourage and guide wiki authors to continually provide content and metadata, then intelligent services could unleash their true potential.

# 6 Scope and reach

At the time of this writing, PlanetMath contains 8945 entries, dealing with 15655 concepts. 298 people have contributed an entry in the encyclopedia, and 2742 have contributed something (perhaps just one forum post).

<sup>&</sup>lt;sup>11</sup>www.jointmathematicsmeetings.org/meetings/national/jmm/san-prog.pdf

<sup>&</sup>lt;sup>12</sup>http://www.dessci.com/en/company/shows/jmm/mow2007.htm

<sup>&</sup>lt;sup>13</sup>http://www.maa.org/abstracts/mf2008-program.pdf

<sup>&</sup>lt;sup>14</sup>http://www.ima.umn.edu/2006-2007/SW12.8-9.06/

<sup>&</sup>lt;sup>15</sup>http://projects.cs.dal.ca/ddrive/seminars/mkm.shtml

<sup>&</sup>lt;sup>16</sup>http://www.scribd.com/doc/9691966/, http://www.scribd.com/doc/9692058/

<sup>&</sup>lt;sup>17</sup>http://metameso.org/~joe/docs/book.pdf

<sup>&</sup>lt;sup>18</sup>http://metameso.org/~joe/math/fem-2005.tar.gz

<sup>&</sup>lt;sup>19</sup>http://code.google.com/p/nnexus/

<sup>&</sup>lt;sup>20</sup>http://statprob.com

<sup>&</sup>lt;sup>21</sup>http://planetphysics.org

<sup>&</sup>lt;sup>22</sup>http://wiki.planetmath.org/cgi-bin/wiki.pl/Feature\_Requests

Out of these, an exceptional group of 24 authors have produced more than 100 encyclopedia articles apiece. Their contributions comprise 74% of the total number of articles. About 71% of this core group joined before 2004 (in the "early days" for the site).

130 users have a score of 1000 points or more, which would correspond to contributing 10 or more new encyclopedia articles, but actually, a significant fraction of this value has been contributed through things like corrections, revisions to existing objects, and posting in the forums. All told, this group has contributed 96% of the total number of articles. About 58% of this group joined before 2004.

According to Alexa.com, PlanetMath.org is currently the 165,011<sup>th</sup> most popular website in the world, comparable to the website of the Mathematical Association of America<sup>23</sup> (119,267<sup>th</sup>), or relative newcomer MathOverflow.net<sup>24</sup> (184,818<sup>th</sup>).

A far cry from competing with Wikipedia, but in fact we like to think of the two projects as mutually supporting. PlanetMath content is reused under the terms of the shared CC-By-SA license in hundreds of Wikipedia articles, and cited in over 1500.

#### 7 A new era

In 2010, a new project to completely rebuild PlanetMath's software began. *Planetary* is based at Jacobs University, Bremen, and led by Michael Kohlhase, with major contributions from most members of his research group (along with the present author).<sup>25</sup> The Planetary system is described in [4]. Planetary is considerably easier to extend than Noosphere: it is currently comprised of around 20 plugins for the popular open source platform, Vanilla Forums<sup>26</sup>, many of which integrate sophisticated software tools previously developed by the KWARC group. Notably, the system now includes support for semantic authoring and flexible metadata interaction, addressing the critiques mentioned in Section 5.

2011 will see the publication of a book chapter discussing the future use of PlanetMath as the core of a problem-based learning system [2], the focus of the author's doctoral studies [3]. With this as a basis for a showcase of innovative uses for the PlanetMath content, and with a well-documented and easy to extend software platform supporting the system, we hope to see PlanetMath become a central integration platform for free software projects working with freely licensed math on the web.

## 8 Conclusion

PlanetMath has been successful as an online community: the software stabilized early on and has required little upkeep, while the site has continued to grow. However, there has been a danger that with the software system running more or less on "autopilot", new features would not be developed. With any luck, this threat is in the process of being eliminated, heralding in the opportunity to build one or more "new" online communities in close relationship to PlanetMath (e.g. a developer community working on sophisticated tools for scientific communication; a learning community using the PlanetMath encyclopedia as part of a remix-driven interactive textbook). We should do a careful evaluation of what has worked and what could be improved for next time. There is not room in the current paper to conduct this discussion, but framework proposed by Resnick *et al.* would be an excellent place to begin [13].

For all of its potential as a software showcase and its possible future role as a player in a larger landscape of related interlinked online communities, PlanetMath should, at least for the moment, be evaluated first and foremost as an encyclopedia. This too would be best as an ongoing task. For now,

<sup>&</sup>lt;sup>23</sup>http://maa.org

<sup>&</sup>lt;sup>24</sup>http://mathoverflow.net

<sup>&</sup>lt;sup>25</sup>http://trac.mathweb.org/planetary

<sup>&</sup>lt;sup>26</sup>http://vanillaforums.org

Coverage	The median entry would be an advanced undergraduate or begin-
	ning graduate topic. PlanetMath is generally considered to have
	more in-depth treatment of technical issues, e.g. of proofs, than
	Wikipedia.
References	Present in many articles, although there is not yet a unified
	database of references or style of presenting them (this is
	planned).
History	315 items, mostly 20th Century or later. <sup>27</sup>
Audience	Consistent with the coverage, there have been 4127 posts in the
	"Graduate/Advanced" forum, 4261 posts in the "University/Ter-
	tiary" forum, and 1199 posts in the "High School/Secondary"
	forum.
Clarity	There is no hard and fast rule. Some articles are minimalistic,
	but precise (e.g. from strong contributors who have have English
	as a second language). Other articles may be verbose and vague.
	In any case, debates over clarity of presentation are intense, and
	a high standard is generally maintained (see Section 4).
Pictures	There are over 600 images, but this is only about 7% of all en-
	tries. A unified database/gallery of pictures might encourage
	more submissions.
Accuracy	At the time of this writing there are 48 outstanding corrections <sup><math>28</math></sup> ;
	more than 14080 corrections have been filed since the site began,
	though 2337 are classified as "addenda", meaning that no mis-
	take is implied, and 9182 are classified as "meta/minor", mean-
	ing that in the entire history of PlanetMath some 2561 real errors
	have been found through the peer review process (and all but a
	few fixed!). Note that these numbers do not take into account di-
	rect changes by authors (and would tend to under-represent error
	fixing in world-editable articles).
Unusual	PlanetMath provides "math for the people, by the people".
Weight	PlanetMath can be used from any browser, and comfortably
	edited from a lightweight laptop or netbook, weighing about 1kg.

Table 1: Succinct review of the PlanetMath Encyclopedia

a quick summary following the outline used by Emma Previato in her review [11] of the *CRC Concise* gives us a look at how PlanetMath measures up (Table 1).

Because the technology that supports the site is special-purpose, we have been able to hone in on what works best for commons-based peer production in mathematics. Features like the autolinker facilitate integration of content, and the corrections system helps avoid messy battles. There is much more work to be done, but at the close of its first decade of life, PlanetMath may be poised to become a encyclopedia in the literal classical sense of a "complete instruction".

<sup>&</sup>lt;sup>27</sup>http://planetmath.org/browse/objects/01Axx/

<sup>&</sup>lt;sup>28</sup>http://planetmath.org/?op=globalcors

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