
AC 2012-3939: USING MEDIAWIKI TO ENHANCE MATHEMATICS LEARNING IN ENGINEERING SCHOOLS

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Using MediaWiki to Enhance Mathematics Learning in Engineering Schools

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Abstract

The increasing use of the Internet as an educational source has led educators to come up with different tools and strategies to enhance the learning experience. One of the tools that has become popular in education is called a wiki. In this note, we present a study conducted in Guatemala where a small group of students started inputting data into a wiki, called `WikiMatematica.org`. One year later, we have about 2,888 visits per day, where only 2% of them are from Guatemala and the other 98% from other countries around the world. Given the high volume of visits to our website, we started collecting interesting data, such as most visited topics, demographics, and traffic intensity per hour. We use traffic intensity per hour as a way of how to use MediaWiki as a supplementary educational tool.

1 Introduction

1.1 Wikis in Education

A wiki is a well known tool for collaborative environment, the concept was developed by Ward Cunningham in 1995. Later, in 2001, Ward Cunnigham and Bo Leuf⁵ define the nature of the wiki as an interface that allows users to edit and create any page in the wiki, without the need to install external plugins to the web browser. Wikis are commonly used as a tool for creating content in collaboration with others and to serve as a source of information. Also, this web tool allows users to discuss and share their knowledge, or to engage in learning with each other in a collaborative way.

Among the different web teaching tools, wikis have gained great reputation as a collaborative environment for students. There are several studies about student collaboration using wikis. Some of them are presented in Boulos², Chao³, and Reinhold⁸. Parker⁷ believes that despite their potential impact on business, the wiki phenomenon has not yet made it to the classroom, either as a research topic or as a teaching method. However, the popularity of wikis has begun to attract the attention of educators, who expect that wikis will facilitate not only communication but also collaborative finding, shaping, and sharing of knowledge, as showed by Minocha and Thomas⁶, Su and Beaumont⁹ and Reinhold⁸.

Tonkin¹¹ suggests that the use of wikis in education should fall into one of these four categories:

1. Single-user. This allows individual students to write and edit their own thoughts.
2. Lab book. This enables students to peer review notes kept online by adding, for example, comments or annotations to existing lecture notes or seminar discussions.
3. Collaborative writing. This can be used by a team for joint research such as a group project, essay or presentation.
4. Creating a topical knowledge repository for a module cohort. Through collaborative entries, students create course content that supplements and extends delivered material.

Some of the findings in a study conducted by Cole⁴ suggested that some of the pedagogical benefits of using a wiki are the following:

1. Evolutionary knowledge building and innovative problem-solving.
2. Explaining diverse and often conflicting ideas.
3. Synoptic assessment and definitional synthesis.
4. Critical questioning and reflection.
5. The ability to avoid premature criticism and engage in complex and nuanced analysis of others work.

Even though all five points are extremely interesting, we believe that the last two are crucial in the learning process through a wiki. We have realized, although not formally tested, that when a student/user is learning from a wiki, he/she does not take what he/she is reading for granted; which leads them to read with critical judgment. One of the reasons of this phenomena may be driven by the nature of the input in a wiki, i.e., knowing that the information was probably inputted by a non-expert person in the field, he/she tends to question the content more than if it was in a book. Therefore, as Cole⁴ mentioned, users study with a critical judgment making them deeply analyze what they are trying to learn.

In the following section we present an introduction to `WikiMatematica.org`. We explain what type of plugins we are currently using in the website, and provide a short description for each of them. In section 3 we present the impact that this website has had and some interesting data we collected throughout the study. Section 4 presents some anecdotal evidence where we included only a few of the hundreds of comments we have gotten regarding `WikiMatematica.org`. Finally, in section 5 we present some conclusions and future work.

2 WikiMatematica.org

In June 2009, we started developing a website with the purpose of engaging students in the classroom and potentially decreasing the student attrition in our math courses. After refining our objectives, we decided to develop a tool that would increase the student's engagement in the classroom, without considering the potential impact in the attrition rate. After several months of developing, researching and testing the right tools that could help us to create the website, in June

2010, we created `WikiMatematica.org`. We invited around 150 Guatemalan students from Galileo University (`www.galileo.edu`), from different engineering fields and stages of their careers, to use `WikiMatematica.org` as a notebook. These students/users were allowed to input the material they were learning in their math courses as well as videos or other explanations they felt were useful for understanding whatever they were learning.

The methodology used to assist users in inputting the content to `WikiMatematica.org` was the following:

1. We created a wiki-page for each math course offered at the engineering school. Each one of these wiki-pages contained an outline of the course content, where every topic of the outline was a link to a blank wiki-page.
2. We asked the student to access a wiki-page of his/her interest and start inputting content to each topic of the outline.
3. To improve the quality of the content we invited teaching assistants and students from more advanced math courses to edit and review each new topic.

Having some content inputted in `WikiMatematica.org` we started advertising it in the following way:

1. We created a Facebook fan page that would allow users to meet other users and, at the same time, allow us to send notifications about new content in `WikiMatematica.org`.
2. We made `WikiMatematica.org` a Search Engine Optimized (SEO)¹ website, i.e., we improved the visibility of our website in search engines, such as Google and Bing. This helped us to be one of the top ten search results in topics such as Laplace transform, integrals, partial fractions, polynomial functions and many others; see Figure 1.
3. Word-of-mouth.

2.1 Plugins

In this section, we describe some of the plugins we are currently using in `WikiMatematica.org`. Even though we present just a few plugins, it is worth mentioning that there are hundreds of plugins available in websites like `http://www.mediawiki.org/wiki/Extension_Matrix`, to customize a wiki as much as the creator/administrator of a wiki wants.

2.1.1 Mathjax

MathJax (`www.mathjax.org/docs/1.1/mathjax.html`) is an open-source JavaScript display engine for \LaTeX and MathML that works in all modern browsers. It was designed with the goal of consolidating the recent advances in web technologies into a single, definitive, math-on-the-web platform supporting the major browsers and operating systems. It requires no

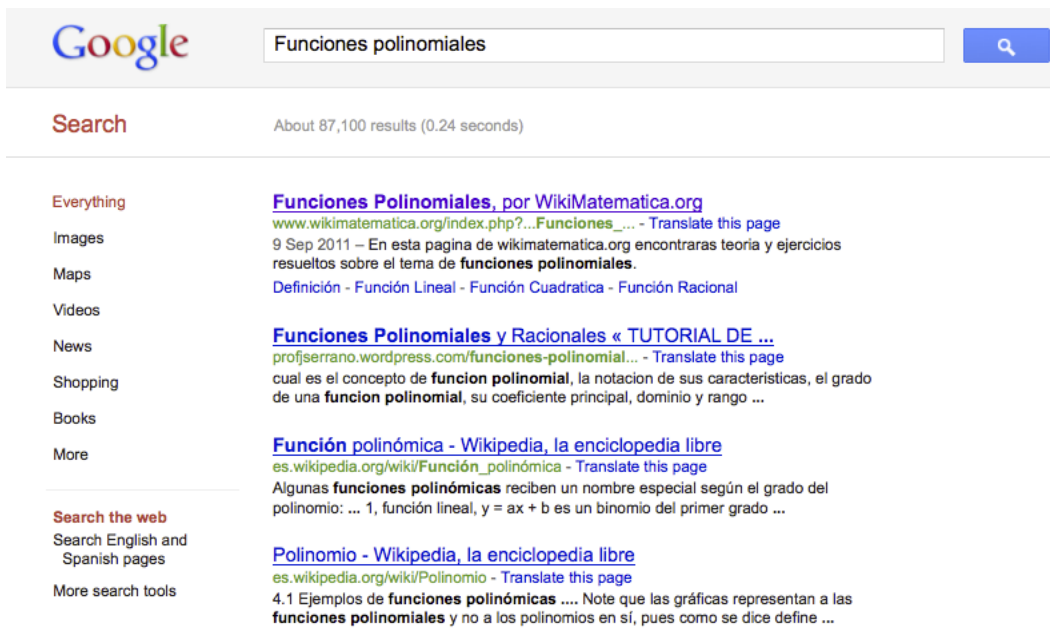


Figure 1: Example of a Google search for "Funciones Polinomiales" (Polynomial Functions).

setup on the part of the user, so the page author can write web documents that include mathematics and be confident that users will be able to view it naturally and easily.

Some of the benefits of MathJax are that it uses web-based fonts (in those browsers that support them) to produce high-quality typesetting that scales and prints at full resolution (unlike mathematical formulas presented as an image). One great advantage of this plug-in is that mathematical formulas are text-based, as in \LaTeX , rather than image-based, and so it is available for search engines. Also, MathJax works only as a display for \LaTeX and MathML, but also allows page authors to write formulas using such formats.

Another benefit of this plug-in is that it can convert TeX notation into MathML, so that TeX notation can be rendered more quickly by those browsers that support MathML natively, so that the user can copy and paste the TeX notation into other programs. Some of the particular benefits we found in MathJax for WikiMatematica.org are that the content can be searchable by search engines and, therefore, it helps users find the content easily. Also, the fact that it supports \LaTeX helps the user to input math equations in an easy way in addition to encourage the usage of specialized text editors for mathematics, like \LaTeX . Finally, one of the big advantages our users have mentioned is that they can copy/paste the content into an email or an assignment.

2.1.2 Tynt

Tynt (<http://www.tynt.com>) is a plugin that inserts a reference to WikiMatematica.org to every copy/paste made by a user. It also saves what was copied/pasted, as well as where it was performed. This helps us to keep track of what users are sharing with other users or friends. Another advantage of Tynt, is that the administrator of the

wiki can access to www.Tynt.com to customize the link embedded on each copy/paste, and also track its behavior.

2.1.3 EmbedVideo

EmbedVideo (<http://www.mediawiki.org/wiki/EmbedVideo>) is a MediaWiki extension that was created by Andrew Whitworth, Jim R. Wilson, and Mohammad Derakhshani. It adds a parser function called `#ev` for embedding video clips from popular video sharing services like YouTube, vimeo and others. In other words, with this extension users can add videos and write comments about it. This is one of the big differences between WikiMatematica.org and other similar websites, such as Wikipedia, where the user cannot include videos in content.

Even though we are not measuring the impact of WikiMatematica.org in the student attrition rate, it is worth mentioning that the following plugin might be conceived as the linkage between academic integration and social integration of Tinto's model¹⁰ for attrition rate reduction.

2.1.4 Facebook Connect

Facebook Connect (<http://www.mediawiki.org/wiki/Extension:Facebook>) is an extension that allows the integration of the wiki to Facebook. Users can log in using their Facebook accounts, comment on articles and share articles to their Facebook wall. This extension was created by Garrett Bruin and Sean Colombo and currently managed by GitHub.

This extension has helped WikiMatematica.org to engage users and also to get new ones. The ability to comment on any article has helped us to identify what needs and expectations the users have with respect to each article. Also, using Facebook Connect, users will socially interact using academic topics. As mentioned above, this interaction works as a linkage between the social and academic integration in Tinto's model¹⁰ framework.

Figure 2 is an example of a user that used Facebook Connect to post to her wall and tag some of her friends so they can see the article. Also, notice that thanks to this plugin we were able to identify a problem in the content and be able to resolve it.

2.1.5 ShareThis!

ShareThis (<http://sharethis.com>) is a platform for sharing content among Internet users and for increasing the influence of a website across the web. By adding this plugin, users can express their preference towards certain topic and make it visible to their entire social network. Currently ShareThis has more than 400 million users across more than 1 million web sites. It is a free service that allows you to put a bar for users to click on when they want to share a wiki article to their favorite social site.



Figure 2: Screenshot showing how users are sharing content with other users via Facebook Connect.

On the first dialog box she makes the following comment “I cannot see the graphs, but the article was really helpful.” In the second dialog box, she tags some of her friends and comments “Lets see if this is helpful to you too.” (The content of the image has been altered to protect user’s privacy.)

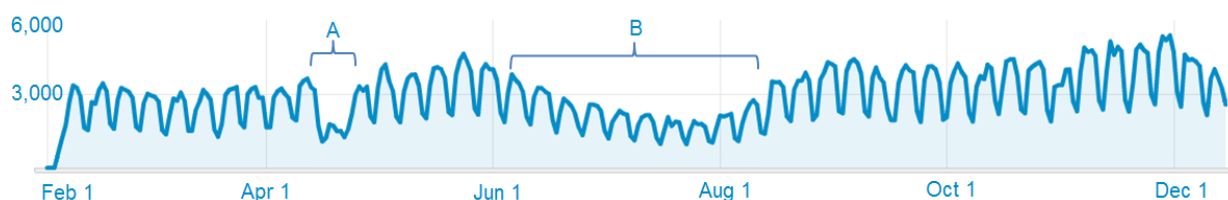


Figure 3: Behavior of the number of visits from February 2011 to December 2011.

3 Impact of WikiMatematica.org

3.1 Utilization

In this section we provide some evidence of the impact of WikiMatematica.org. Even though we launched the website in June 2010, we started collecting data using web analyzers, such as Google analytics, in February 2011. We have had around 900,000 visits between February and December 2011, where 81.23% of them represent new visitors and 18.77% returning visitors. Figure 3 shows the behavior of the number of visits in the mentioned period. Up to December 2011, the average number of visits was 2,888 visits per day, with a standard deviation of 1,038 visits, a maximum of 5,377 visits and a minimum of 610. Notice that one of the main reasons of the high variability is due to the Easter Week (spring break), denoted by (A) on the graph, and summer break, (B) on the graph. This behavior was surprising because in most Latin American countries the academic year runs from January to December, and there are only a few weeks of break during the summer. This shows that some of our users comes from Spanish-speaking people residing in countries outside of Latin America.

In order to segment our population depending upon country of residency, we also collected the country and city from which users were accessing our website. Figures 4 and 5 show the distribution, per country, of visits to WikiMatematica.org around the world. Even though the original target population of WikiMatematica.org was students in the 17 to



Figure 4: Distribution density of visits.

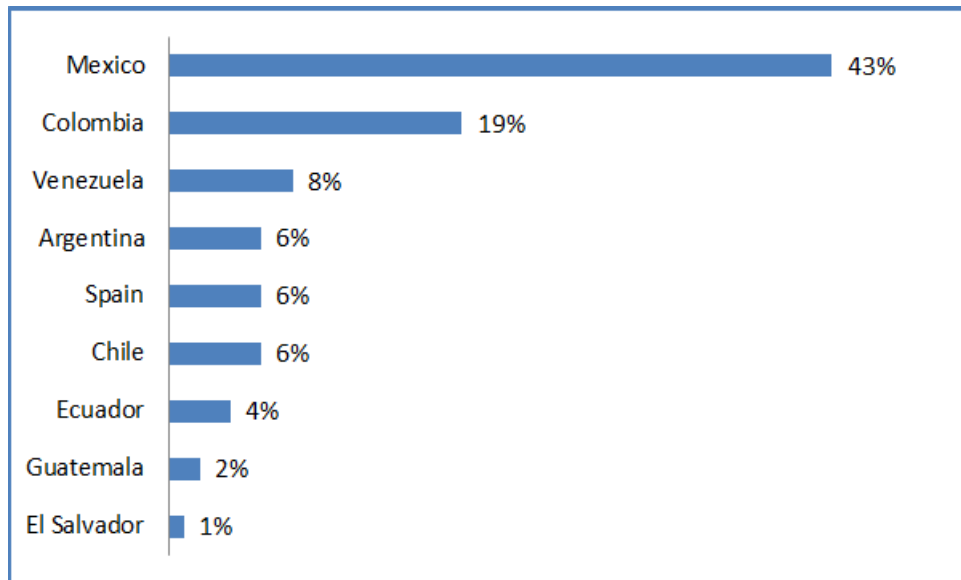


Figure 5: Top 10 (out of 108) countries visiting WikiMatematica.org.

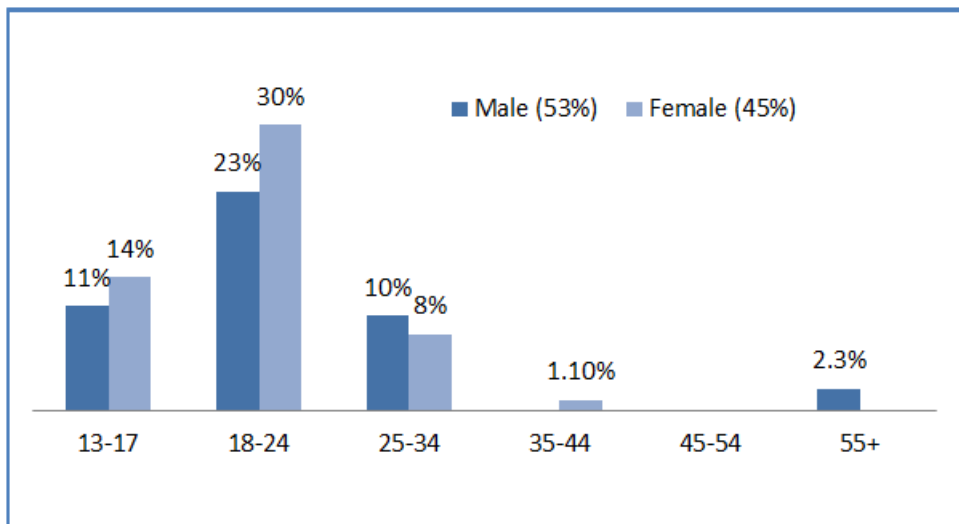


Figure 6: Current population distribution by age.

21 year old range, currently 96% of our users are between 13 and 34 years old, as presented in Figure 6.

3.2 Most searched topics

Right now `WikiMatematica.org` is one of the top ten search results for topics such as Laplace transforms, integrals, partial fractions, polynomial functions and many others topics. For us, as mathematics educators, knowing which topics are causing more difficulty to our students is interesting and valuable data. Therefore we kept track of the most visited web pages, topics and graphics in `WikiMatematica.org`, with the intention of detecting areas of opportunity to improve our website and probably the curricula of our courses. Table 1 presents the top 15 most searched topics, in `WikiMatematica.org` by Spanish-speaking students around the globe. It is worth mentioning that we have an extended list of 20,130 items including images, discussion boards and articles, that can help us to identify, with a high level of detail, what our users are having problems understanding in the classroom.

3.3 Supplementary Education and Sustainability

We were interested in whether or not a website like `WikiMatematica.org` can be used for supplementary education. Also, we wanted to compare the benefits provided by the website over those of traditional (in-class) supplementary education. In order to investigate this, we studied the economic sustainability and the hourly usage of our website. The latter was measured in terms of percentage of users connected at a given time of the day.

3.3.1 Supplementary Education

The traditional supplementary education usually takes place at certain specific time and place. The academic institution will assign a class period so that the students can attend and clarify

Table 1: Ranking of the 15 most searched topics in WikiMatematica.org

Rank	Topic
1	Partial Fractions
2	Polynomial Functions
3	Increasing and Decreasing Functions
4	Basic Integration Rules
5	Trigonometric Integrals
6	Arithmetic and Geometric Sequences
7	Trigonometric Functions
8	Partial Derivatives
9	Sigma Notation
10	Inverse Laplace Transform
11	Cylindrical and Spherical Coordinates
12	Riemann Sums
13	Properties of the Exponents
14	Binomial Theorem
15	Taylor and Maclaurin Series

Table 2: Some of the Latin American universities that have a link to WikiMatematica.org from their website.

Rank	Institution	Country
1	Universidad Galileo	Guatemala
2	Universidad de Guadalajara	Mexico
3	Instituto Tecnológico de Monterrey	Mexico
4	Universidad Nacional de San Martín	Argentina
5	Universidad Estatal a Distancia	Costa Rica
6	Universidad Alas Peruanas	Peru

questions related with the material they are learning. With this traditional approach, students do not have the flexibility of studying whenever they want (or can), which may lead to the loss of the student's willingness to learn. In addition, given the lack of flexibility of the traditional supplementary education, students may have a time conflict that will lead to a low attendance for such an important part of the educational process.

Using WikiMatematica.org as supplementary education, students have access any time of the day and can learn not only from the content but also from the comments and suggestions made by other users. Currently, Galileo University, and many others (see Table 2), are recommending to their students that they visit WikiMatematica.org for more examples and explanations in several areas of mathematics. Also, in order to provide more evidence of the potential use of wikis as a tool for supplementary education, in Figure 7 we present the usage distribution of WikiMatematica.org throughout a typical day.

Note that about 90% of the users are using WikiMatematica.org during the regular class

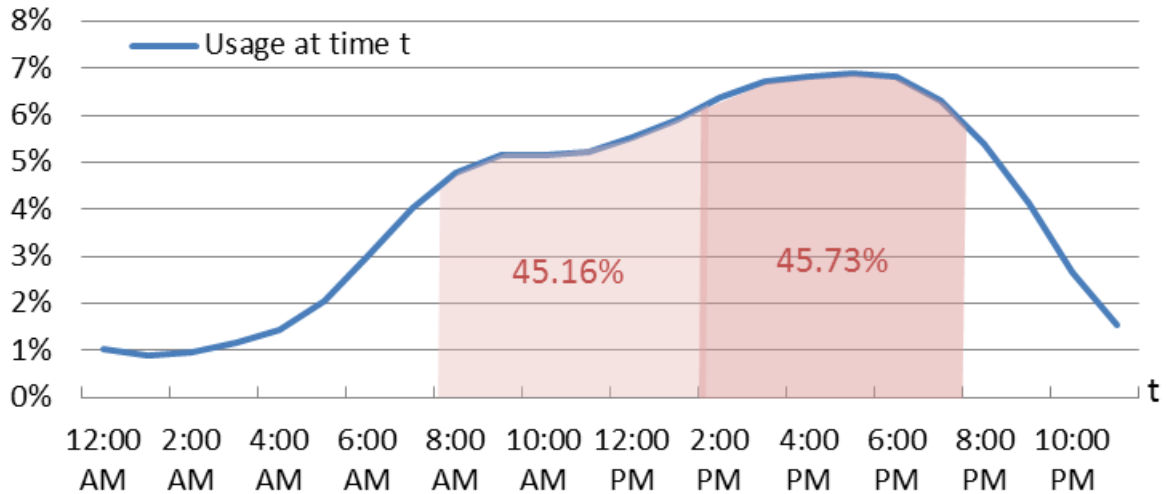


Figure 7: Usage distribution of WikiMatematica.org in a typical day.

Table 3: Approximate yearly cost of maintaining a wiki (in USD).

Item	Cost
Hosting of the website	\$130.00
Domain	\$ 10.00
Labor	-
Total Cost	\$140.00

Note that the total cost does not include labor.

time; from 8 a.m. to 8 p.m., suggesting the necessity of having supplementary education open during the whole day, rather than a few hours a week.

3.3.2 Sustainability

The cost of the traditional supplementary education takes into account costs of faculty and venue. These costs are usually not so low and varies between countries. We encourage the reader to compare such costs to the cost of maintaining a wiki, such as WikiMatematica.org, provided in Table 3. Note that the labor cost is ignored because the wiki is usually administered by the same faculty who is teaching the course. Also note that the cost of hosting can be really low (if not zero) if the wiki is hosted by the academic institution where the wiki will be implemented.

WikiMatematica.org is sustained using Google Adsense, which is a service of banner advertising where any person can sign up and display ads provided by Google in their websites. The owner of the website gets paid a small amount of money per click that each user makes on the banners. Currently WikiMatematica.org has an average revenue of \$0.50 a day for a total of \$183 a year. This amount takes care of the cost of hosting and domain.



Figure 8: "Excellent website."

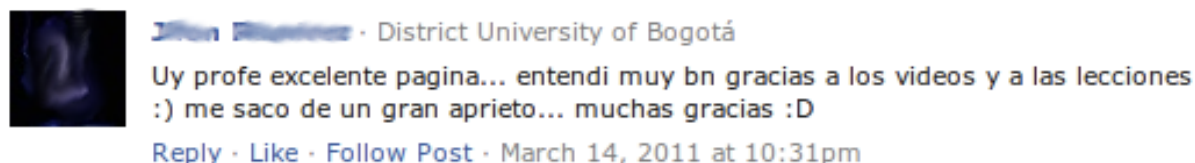


Figure 9: "Excellent webpage...the videos and lectures helped me to understand very well..."

4 Anecdotal Evidence

In this section we collect some user's comments regarding our website. Since we have a Spanish-speaking population, the comments were translated. It is worth mentioning that we neglected hundreds of great comments about the website because of the poorly written Spanish. Figures 8–12 collect comments from users ranging from professors to college students. (The content of the images has been altered to protect users' privacy.)

5 Conclusions and Future Work

The current necessity of learning how to use new teaching tools that fit the contemporary world has made us investigate the impact of a well-structured wiki. *WikiMatematica.org* has become popular among Spanish-speaking users in many countries around the world. After collecting 2,888 data points on average per day, during a year, we were able to detect interesting behaviors such as the most searched topics in mathematics, among those available in *WikiMatematica.org*. Also, we collected the time of the day that our users are connected to *WikiMatematica.org* and use this data to show that a wiki can be an excellent candidate for supplementary education in comparison to the traditional in-class supplementary education, which is less flexible and probably more expensive.



Figure 10: "I learned more here than in the classroom, very good."

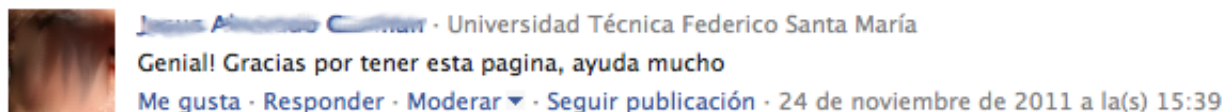


Figure 11: "Great! Thank you for making this website, it helps a lot."



Figure 12: "This website helps me a lot...I can understand my math course better."

The style, presentation, and plug-ins used in `WikiMatematica.org` have helped to increased its popularity. Also, the integration of different social media plugins help students share content with their classmates and discuss it in their social media site.

We found several leads to be followed after this study. The first one is to study the impact of tools, like `WikiMatematica.org`, to the student attrition rate. Second, we are investigating how many revisions it takes to have a good quality article in a wiki. We need to find how many revisions have to be done to an article that guarantees certain level of quality, where the standard is set depending on the target population.

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