Effective use of Wikis in College Mathematics Classes

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ABSTRACT

Wikis are used in mathematics education in a variety of ways [3]. As with *Wikipedia*, mathematics related Wikis provide pages and links that describe many different branches of mathematics. Another common use is as a portal for distributing and collecting mathematics course materials [1]. This article describes the authors' use of course wikis for two different purposes in two undergraduate math courses. In Calculus-I, a wiki was utilized to share and present the outcome of an optimization problem that required small groups to collect information about student homes' attic insulation status and eventually to compute the optimal amount of new insulation to add that maximizes heating savings. The second wiki was for a small seminar-style course on *Mathematical Mysteries* where students collected and posted the results of their research relating to famous unsolved problems in mathematics. This wiki was also used as a platform for in-class presentations by the students and the instructors. In both cases, the bulk of the wiki contribution was by students.

Keywords: Science and Mathematics Education, Technology, Distance Learning, Wikis, Collaborative Learning.

1. INTRODUCTION

Although Wikis are generally used to provide a collaborative learning environment in education, it is hard to find examples where students contribute significantly to course-based Wikis in mathematics. We developed a Mathematics Wiki Project for Calculus-I students at the University of Wisconsin Marathon County in fall 2008 followed by a second Wiki project in the fall of 2009 for a special topics course titled *Mathematical Mysteries*. The two courses were quite different in nature and the Wikis themselves served two very different purposes. The objective of this paper is to share our experiences with these projects, from the point of selecting the Wiki and the topics to how students engaged and performed in the projects. The first Wiki assignment was a "field project" where groups of 3-4 students selected a house and used calculus to find the optimal depth of additional attic insulation which would provide the maximum savings on heating/air conditioning over a period of years. The second involved individual students researching a collection of mathematical conjectures and using the Wiki to collect and share their findings.

2. WHAT IS A WIKI?

A Wiki is a piece of software which allows users to easily create, edit and put together a collection of web pages without the need for an overall administrator. As used in an instructional setting, they are basically smaller localized versions of the popular "Wikipedia" (www. http://www.Wikipedia.org/). What makes Wiki's attractive is that little or no programming skill is required, they are easy to maintain, documents can be easily formatted, edited and linked, images and other media content can be readily imbedded, multiple users can have access to facilitate collaboration, and they are inexpensive (free options exist).

Our use of a Wiki for mathematics came to mind in the fall of 2008 when our University linked a media Wiki engine to the course management sites and encouraged faculty to submit pilot projects. Our first task was to find a suitable Wiki engine (or a Wiki Farm as these are now known) for the project. Since the Wiki initiative came halfway through the semester, we had very little time to make a selection. We compared the potential benefits of Media Wiki and (www.Wikipsaces.com) and selected Wikispaces for its WYSIWYG interface and superior ability to incorporate Mathematical Equations.

3. SELECTION OF THE WIKI PROJECTS

We spent a considerable amount of time selecting an appropriate project for Wiki use. We decided that having students post solutions of routine mathematics exercises on a Wiki would not be an optimal use of this shared space since most students would use the same routine steps to get the answer. Also, once a student posts a solution, the other students in the group would have little to contribute, thus failing to utilize the collaboration potential of a Wiki.

Collaboration is most needed when the problems are challenging and one person's input is not usually enough to finish the task. Most routine problems that you encounter in standard textbooks on Algebra, Trigonometry, Calculus etc., are not challenging enough for Wiki project. Also, CAS-calculators and available on-line applets can perform such calculations with no indication of students' understanding. Other than facilitate Collaborations, Wikis can also encourage creativity and critical analysis of others' work, skills that encompass the higher levels, *apply, analyze, evaluate and create* in Bloom's Taxonomy of cognitive tasks.

We then started looking for a mathematics project requiring enough challenge, creativity, originality, and collaboration, to make good use of the tools available in a Wiki. Around this time, while thinking about real-life applications, we recalled a college algebra project we'd used years earlier on quantifying the heat-loss from a home through its attic. In that project, students computed the annual heat loss through the attics of local homes. The heating cost savings function can be derived as a function of the thickness of insulation to be added, and as a calculus project, this function can be differentiated to find the critical thickness which will maximize the savings. It was felt that this would be an excellent candidate for a Wiki project because: The project is multi-stage, accessible and of potential interest to students and could save their parents significant money; Collaboration is useful since numerous data such as attic measurements, local temperature averages, and insulation and energy costs must be brought together; A Wiki would facilitate extended group work on our mostly commuter campus; Each group could easily access and critique others' results in the final product. Further details and results are given in section 4.

In Fall of 2009, we decided to utilize a Wiki in a different capacity to enhance a small seminar-style course "Mathematical Mysteries" in which we study the history, evolution of, and current status of some of the famous mysteries in mathematics such as Fermat's Last Theorem and the Goldbach Conjecture. The selected problems have been evolving for quite a while, and there are abundant stories, historical episodes, attempts at proofs, and technical articles surrounding them. We felt that having students research and bring together some of these facts and lore related to each mystery through Wiki pages would be a useful and productive exercise. Our emphasis here was to use the Wiki as a repository of students' individual research on the topics rather than structured collaboration with each other. This is similar to an application by Robert Talbert in [2]. A more detailed description of both Wiki projects follows.

4. DESCRIPTION OF THE WIKI PROJECTS

Project 1: Using calculus to find optimal thickness for attic insulation.

Mathematical Background: The mechanism of heat loss through the ceiling of a home is primarily by conduction. Thus the rate of heat loss across the ceiling varies jointly with the temperature difference between the interior and the attic $(T_i - T_a)$ and with the area of the ceiling. The constant of variation in suitable units is the inverse of the R-value of the ceiling-attic insulation layer. Specifically, if the area is in square feet and the temperature difference in degrees Fahrenheit, the rate of heat loss in British Thermal Units per hour is

$$r_{hl} = \left(\frac{1}{R}\right) A (T_i - T_a) \frac{BTU}{hr}. \qquad (I)$$

When the average temperature difference over a whole day is added up over all the heating days of the year, this sum is called the Heating Degree Days (HDD) for that location. The annual heat loss is then given by

$$Q_h = \frac{A * 24 * HDD}{R}. \qquad (II)$$

From equation *(I)*, we see that there are three means to reduce heat loss through the attic: Reduce the square footage of your ceiling; Make the temperature difference less, i.e. turn down the thermostat; And increase the R-value by adding insulation to the attic. This project deals only with the latter of these and aims to determine the optimal depth of new insulation to add to achieve maximum cost savings over a fixed period of years.

For our project we had students work in small groups that measured the ceiling square footage and current insulation status of the ceilings in two or more homes of students from each group. In addition, the type of heating system was identified and an estimate of the furnace efficiency was made to compute the total cost for heat loss through the ceilings in a year. In 2009, local natural gas costs were ~\$1 per 10^5 BTU. Thus a 90% efficient furnace supplies heat at $c_h = \$1/\,90{,}000\, BTU$. For electric heat with electricity at \$0.12 / $(kw \cdot hr)$, $c_h = \$1\,/28{,}500\, BTU$. The annual cost for heat loss through the ceiling is given by:

$$C_h = c_h \frac{24 * HDD * A}{R}. \qquad (III)$$

The value of R is determined initially and after adding x inches of insulation, and then the annual savings is computed as a function of x. Using local costs of insulation material, students computed the cost to add x inches to the attic for this one-time cost. Finally, the ten-year net savings is computed as a function of x. By using calculus (or simply plotting a graph) the maximum value of this function can be located.

Example: Professor Martin's Home in Wausau, WI initially had 3" of blown-in fiberglass insulation, 1100 square feet of ceiling space, and a heating system that supplied heat at $\$1/80{,}000\, BTU$. New cellulose insulation costing $\$0.40/ft^3$ was to be added and the local $HDD = 7834$. The initial R-value was $R_i = 7.6$ and the net savings function (over 10 years) for adding x inches of insulation was

$$S(x) = \left(1100 \times 24 \times 7834 \times \left(\frac{1}{7.6} - \frac{1}{7.6 + 3.1x}\right) \times \frac{1}{80{,}000}\right) \times (10) - 0.40 \times \frac{x}{12} \times 1100. \quad (IV)$$

Graphically or analytically, the maximum net savings was ~\$2385 over ten years when 12.6 inches of insulation were added.

The Wiki was named "marathoncalc" and was hosted with the main organizer site at http://marathoncalc.Wikispaces.com/ . We created 8 groups K1,K2,K3 ,K4 (For Kirthi Premadasa's section) and P1,P2,P3,P4 (For Paul Martin's section) and invited the students of all 8 groups into the Wiki with a separate page for each group. For example, the group P4 pages and results can be seen at http:// marathoncalcp4.wikispaces.com/ . In the main organizer page, a sequence of six guided tasks was given to guide the students through the project. Some of the important formulas were given but the main calculations in equations (I) and (II) were developed by each group. Students then had to set up the savings function, differentiate it and get the critical value to determine the optimal insulation thickness.

Observations: The student groups selected one or two houses of the group members, entered the data and then proceeded with the calculations. Even though students were able to grasp the individual components of this project, they had a difficult time putting them all together and a lot of discussion was needed for some of the groups to come to their final product. Not all groups completed all components of the project due to our starting this in week 12 of the semester. In the future, we will likely use weekly progress discussions in class or use the Wiki itself to provide feedback and guidance to the groups as the project proceeds.

Project 2: Researching Mathematical Mysteries

The Course (and the Wiki project) researched information about the following famous Math Mysteries.

- The odd perfect number problem
- The search for Mersenne Primes.
- The Goldach Conjecture
- Fermat's Last Theorem
- The Four Color Problem
- Collatz Conjecture
- Catalan's Conjecture
- Twin Prime Conjecture
- Distribution of Primes
- The Riemann Hypothesis

Once again, Wikispaces was used as the Wiki engine. The Wiki was named "mathpuzzles". The main organizer website is at http://mathpuzzles.Wikispaces.com/. Each of the nine students enrolled in the course was invited to join and asked to develop their Wiki pages. In each class, a problem was discussed and selected students were asked to research some aspect of the problem and present their findings in the next class session through shared documents on the course Wiki. Examples of several student's work can be seen at http://mathpuzzles.wikispaces.com/Rich%27s+wikipage and http://mathpuzzles.wikispaces.com/Reba%27s+wikipage .

Observations: The level of effort that students put in the individual pages varied significantly. While some students clearly researched and found significant information to complete their assignments, there were a few who simply resorted to cutting and pasting from Wikipedia. For example, when asked to research the latest Mersenne Primes that were discovered one student simply pasted in a current table from a website. In some sense, this is partly what we wanted of this Wiki, i.e. to collect information from many places. However, in the capacity of collecting others' results and research, our students' work should focus on organizing and making a useful web document with relevant links. In another situation, a student spent a lot of time on an assignment to discover a partial proof to Catalan's Conjecture during medieval times. This turned out to be fairly difficult but the student made a significant effort to find it.

The facility available in Wikis to insert images, URLs and equations helped students to make their assignments more clear and comprehensive. When the students were presenting their assignments in class, they simply logged on to their Wiki from the classroom computer and projected their Wiki on to the screen. This saved valuable classroom time and was easier than making up PowerPoint slides or sharing printed documents. The students were able to find some exciting facts about these famous problems which are generally not known. Now they have been archived and anyone interested can visit and view the Wikis long after the course is finished.

The lack of a simple equation editor such as is available in MS Word is a minor drawback for beginning undergraduate students in mathematics. Wikispaces would only accept equations in LaTeX which can be a bit time consuming for beginning students who are more familiar with the MS Word equation editor. A website which does LaTex Conversion was provided to students, but not everyone used it.

5. SUMMARY

Wikis provide a very useful platform for implementing collaborative assignments in mathematics. Our project choices of an extended real world application and an integration of information from the students in the class both worked well. During the insulation project, students appreciated the flexibility of working through the wiki, since they mostly commute from a fairly large area. Students were able to present from the Wiki itself and the instructors simply visited the Wikis to observe student work (and give feedback). This is a significant time savings advantage in Wikis. Even after the project was finished, the findings are freely available to the general public. (If desired, the Wiki can be made private too.)

The Wiki allows instructors to track individual contributions made by students which we found useful for assigning grades. Students can be asked to evaluate the work done by other students through the Wiki. Unfortunately few students did this through our Wikis even though it is quite likely they argued within their groups. The ease of copy and paste can lead to plagiarism and the assessment of actual student work can be difficult. This showed up in the Math Mysteries Wiki and we addressed it as the semester progressed. Overall we felt that these projects were enhanced by the use of Wikis and we look forward to their continued use in these and other classes.

6. REFERENCES

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