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Implementation of interactive Web-based training tools in pavement engineering

Pavement Interactive, an online pavement community built on an open-source wiki platform, is a novel and possible approach to giving distance training to South African and southern African roads professionals in various aspects of road construction, maintenance and management

The original paper, of which this article is a substantially shortened version, and which received a Commendation (Pavements) from the SAICE Transportation Division at their Chairman's Luncheon in April this year, was co-authored by the following people, all from the University of Washington:
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INTRODUCTION

South Africa is experiencing a dire lack of technically trained technicians, technologists and engineers to cope with the demand that the expanding road network places on construction, maintenance and management to keep it in a serviceable condition. The lack of appropriate technical knowledge is another hampering factor, leading to an unacceptable deterioration of the condition of the infrastructure (Lawless 2005, 2007).

The only feasible method to counter this is to invest in endowing staff with the necessary technical knowledge. Not many tertiary institutions offer pavement engineering as a specialist field of training, and therefore the information that most engineers have about pavement engineering is typically limited. With the major need for specifically maintenance and rehabilitation of road infrastructure in the developing world, it is important to search for alternative methods to provide the required pavement engineering concepts and information to the broader engineering community. Traditional courses and lectures fulfil part of this role, but the sheer number of students who require this type of training, together with the long distances that they often have to travel to attend formal training and education in pavement engineering, usually makes such courses unfeasible for the majority of students and practitioners in the developing world.

Although self-paced learning is unlikely to take the place of formal lecturing and coursework, it does fulfil an urgent need to ensure exposure to correct information regarding pavement engineering. The need for access to reliable educational and training material on pavement engineering is thus real. Web 2.0 technologies are a novel approach to addressing this training requirement from a distance.

BACKGROUND TO PAVEMENT INTERACTIVE

Web 2.0 is a general term used to describe the latest generation of the World Wide Web which focuses on collaboration and information sharing rather than just the placement of information online. Pavement Interactive (PI) (http://www.pavementinteractive.org) is an ongoing experiment in leveraging Web 2.0 ideas to improve pavement knowledge transfer on a worldwide basis. It is an online pavement community built on an open-source wiki platform. It went live online in September 2006 and as of March 2009 had logged over 1 million page views and 20 000 edits. It contains over 500 web pages' worth of information and is viewed worldwide on a daily basis.

As opposed to information transfer, "knowledge transfer" implies that some knowledge is gained by the receiver. Most research suggests the chief barriers to knowledge transfer are time and money (Mericka 1992; O'Shaughnessy 1992; Muench & Mahoney, 2004). Specifically, work schedules are often full and cannot accommodate scheduled training sessions. Often, distances to locations where training is presented also hinder attendance. The idea of

instantaneous training is sometimes referred to as "just-in-time training" and often the medium of choice for such training is online. The American Society for Training and Development (ASTD) reports that e-learning in 2007 constituted 32,6% of corporate learning hours (Paradise 2008).

The Web nowadays is capable of more than static electronic displays of information as in Web 1.0. Web 2.0 characterises the Web as a platform spanning all connected devices delivering continually updated services capable of sharing and remixing information between users, with the key characteristic that the service gets better the more people use it. The following seven core competencies of Web 2.0 companies are the essential ideas of Web 2.0 as they translate to knowledge transfer in the pavement community (O'Reilly 2005):

1. Unique quality content
2. Service and not product
3. Users as co-developers
4. Harness collective intelligence
5. Serve the individual user rather than the large organisation
6. Software usable by multiple devices
7. Simple applications and development models.

To date, the pavement community has had little success in leveraging Web 2.0 core competencies to extend knowledge transfer. A rough survey of a website that allows user interaction through user-generated content shows three basic categories of activity in the pavement community: blogs, newsgroups and wikis.

Pavement Interactive is an online pavement community built on an open-source wiki platform. It is one of several research efforts sponsored by the Pavement Tools Consortium (PTC) (consisting of Departments of Transportation of various states in the US and the Federal Highway Administration). It is a wiki, which is a collection of web pages that allow any user to contribute or modify content using a simplified mark-up language. Because of their open nature and simple structure, wikis are often used as the principal software in collaborative and community websites.

Pavement Interactive resides on commercially hosted servers and is built using open source software. The development of content within Pavement Interactive is, in part, a study in evolving publication technologies. In a continuing effort to improve reach and impact while minimising development and maintenance costs, the development team tries to take advantage of existing and readily accessible technologies from a wide array of sources, including open source software and commercially supported services from Google applications. Pavement Interactive consists of *Articles*, *Categories*, *Portals* and *Namespaces*.

At its inception, Pavement Interactive was populated with substantial content that came from a 20-year development effort that had started as a manual of local, national and international pavement practice for the Washington State Department of Transportation. Each development step substantially increased the sophistication and reach of the basic content (Table 1).

"Participation" refers to user actions that contribute to expanding the amount and quality of content, which essentially amounts to an accounting of user edits. Since Pavement Interactive went live, there have been about 965 000 page views and 20 000 page edits. There are 565 registered users, of whom 56 have contributed (10%). There appear to be three major groups of contributors. First, a core group of four users (0,7%) from the University of Washington account for about 10 000 edits (about 50%). Second, a group of students account for about 6 000 edits (about 30%) resulting from class offerings and, finally, a group of PTC (Pavement Tools Consortium) members account for about 700 edits (about 3,5%) (PTC comprises the Departments of Transportation from Washington, California, Minnesota, Texas, Illinois, Idaho, Kansas, Maryland, Florida and the Federal Highway Administration).

One common phenomenon encountered in participatory environments on the Web is that most users will only view content, while few will actually contribute content and even fewer will contribute a majority of the content. This has often been stated as the 90-9-1 rule, where 90% of users merely view content, 9% contribute content in some fashion, and 1% account for most contributions (Nielson 2006).

As Pavement Interactive has evolved, there have been concerns about content dominance by a small group of contributors. Content created in earlier versions

Table 1 A comparison of major products by media, features and estimated reach

	Paper-based	Electronic: pdf	Electronic: html	CMS Web-based	Wiki Web-based
Media	paper	pdf file on CD	html files on CD and Web	Web	Web
Release	1993	1995	2001–2005	never	2006
Pages[a]	800	800	275	296	513
Pictures	233	473	2 500	2 500	3 000
Animations	none	0	50	50	115
Videos	none	1	14	14	65
Development estimate[b] (person hours)	3 000	500	2 000	400	800
Estimated reach	50 copies	500 copies	7 000 copies unknown Web visits	none	75 000 visitors/year

a. For paper and pdf versions, this represents the number of physical pages in the document. For Web-based versions, this represents the number of Web pages in the product.

b. Gross estimates of time spent. This should not be used to forecast new development efforts as technologies have changed and content is likely to be different. Also, development of each version was predicated on the previous version content being updated and reused.

and moved over to populate Pavement Interactive has been verified by independent external review. However, new articles created in Pavement Interactive are typically reviewed only by the authors of this article. To date, this has not been a concern, but it could present future problems as interests may be deemed not broad enough to maintain a national or international perspective. Open invitations to PTC members and others to contribute articles have met with limited success. Knowledgeable individuals are typically too busy to contribute. This has led to one approach that targets researchers and academics for content as they may have the greatest motivation to contribute: researchers in an effort to disseminate results and academics in an effort to provide content that they can use directly in instruction. Encouraging efforts with South Africa are currently under way at the CSIR and the University of Pretoria for making major contributions.

TYPICAL APPLICATIONS AND USES

Pavement Interactive use is worldwide (198 countries) and growing substantially. It appears that the bulk of activity on Pavement Interactive is centred on using the technical articles as ready references or just-in-time training.

Google Analytics data suggest Pavement Interactive is being used primarily as a ready reference and learning tool. This usage pattern suggests that few users are likely to take advantage of the full suite of Pavement Interactive services. In general, the vast majority of users tend to access Pavement Interactive by going directly from a search engine result to an article. Comparatively few (4,35%) see the home page. This implies that most users may be unaware of other Pavement Interactive features. Judging from the average page-viewing time (1 minute, 8 seconds), most users do not access a page long enough to read its entire contents. This means users are likely to leave the page immediately because it is not useful to them, or quickly scan the page for their desired information. This second behaviour strongly suggests Pavement Interactive's use as a just-in-time learning tool where users are looking for only a small amount of information, but tend to demand it in a timely manner. Users coming from university and US Department of Transportation websites, or who are directly accessing Pavement Interactive by typing in a URL, tend to have substantially lower bounce rates and more page views per visit (7 to 10 page views) than the average (4,75 page views per visit). This suggests that these users are engaging in multiple topics in their visits and perhaps using Pavement Interactive as a training tool.

Pavement Interactive is used as the primary reference for four courses at the University of Washington (UW) and also as a reference source in pavement engineering courses at the University of Pretoria (UP). It is used as the primary course website for one graduate class at UW. An assessment of how well Pavement Interactive has been able to incorporate the seven Web 2.0 essential ideas discussed earlier indicates the following:

Unique quality content. Pavement Interactive contains 511 articles of content generated from a 20-year writing and publishing effort. This content uses a citation style similar to that of a refereed journal article and content has mostly been reviewed by subject matter experts. This idea has been fully incorporated.

Service and not product. Early attempts at electronic delivery of Pavement Interactive content were essentially products, therefore the content was essentially static and isolated from user interaction. The wiki format used by Pavement Interactive has attempted to move this content into a service model, but the collaborative uses have not been popular. It appears that Pavement Interactive is a service that gives access to the 500 or so content articles but it has not, to date, generated significant online collaboration.

Users as co-developers. New features are added as they are developed. There is no set version release schedule. However, the addition of Pavement Interactive Maps is a substantial new direction. Over 900 000 page views in 2,5 years of existence suggests that for much of the pavement community Pavement Interactive is not being treated as a research effort.

Harness collective intelligence. The wiki platform on which Pavement Interactive runs provides a straightforward avenue for anyone to contribute to or write new articles. So far participation has been limited to a few main contributors, but it appears that a small percentage of registered users making most of the edits is an established pattern of behaviour in wikis. Therefore, Pavement Interactive has yet to incorporate this idea.

Serve the individual user rather than the large organisation. Most articles in Pavement Interactive are not organisation-specific but organisations can create their own pages and write organisation-specific information if they choose. To date, not much of this has been done. There is therefore room to accommodate both the individual user and the large organisation.

Software usable by multiple devices. To date, Pavement Interactive has not been tested on non-PC platforms. Plans are in place to accomplish this in the next round of development. This idea has not been incorporated.

Simple applications and development models. With a wiki, the only editing needs are a Web browser and an Internet connection. No special software is needed and training on editing mark-up is available in the Help sections of both Pavement Interactive and Wikipedia. However, the current Pavement Interactive editor is not intuitive and relies on its own mark-up shorthand rather than the more familiar what-you-see-is-what-you-get (WYSIWYG) editor that major word processing programs and blogs use. The developers are searching for a more intuitive editor.

Over the last two years, the Pavement Interactive development team has put more effort into encouraging participation since it appears that community website efforts that do not address participation directly are not likely to succeed in the long term.

It appears organisations are seeking products that contain readily accessible information about their standard practices or local conditions. Pavement Interactive addresses these needs by allowing organisations to create their own content and by allowing custom navigation through user portals. Despite this, little content has been added by organisations. The inference is that the most valuable component of an effort such as Pavement Interactive is the writing of quality technical content.

SA-SPECIFIC APPLICATIONS

The open nature of the wiki allows anyone to contribute articles. Therefore, countries or regions can contribute articles that are of specific use to them or that focus on specific local pavement issues (such as specific problem soils or environmental conditions). In an attempt to start such a southern African focus with information of local interest, pavement-related topics that are unique to South Africa have been identified and are currently being prepared for and added to Pavement Interactive in the CSIR/SA portal. The emphasis is on information that needs to be added to ensure that South African practices are clearly described and referenced. Up to March 2009 the following information had already been added to the wiki:

- General CSIR information
- Design and construction of surfacing seals – TRH13
- HVS-related background information
- International HVS locations

Information from the Pavement Interactive wiki was included in the reading material and class notes for the 2008 Tshwane University of Technology BTech courses on pavement design and asphalt design, as well as the University of Pretoria honours course in pavement design and second-year pavement design. It was found that especially the interactive articles and demonstrations allowed students to understand some concepts better. During the discussions on potential uses, required improvements and additional information required, several potential problem issues were identified.

It is important to address access to the Web for typical South African users, as a lack of suitable access will hinder the application of the site. In general, this country's broadband services are much more expensive than internationally. However, these costs tend to decrease, and over time the cost of the service should be comparable to international costs. Of more importance is access to adequate broadband services, but most of the country is covered by broadband access of some kind, through either fixed lines or mobile services.

The specific pages on Pavement Interactive are typically less than 100 kb in size, with the majority being even less than 50 kb. In April 2009 ADSL broadband costs in South Africa started at around R49/Gb, while wireless broadband costs started at around R200/Gb. This translates to a typical cost of less than R0,049 (broadband) or R0,2 (wireless) per article for access to Pavement Interactive in South Africa. Viewing all of the current 511 articles in Pavement Interactive should thus cost less than R25,04 (broadband) or R102,20 (wireless).

CONTRIBUTION OF PAVEMENT INTERACTIVE TO INDUSTRY AND FUTURE DEVELOPMENTS

In order for Pavement Interactive to succeed in its role as training tool, it is important that it actually reaches the intended market. The main contribution to industry is that a central on-line link to a host of pavement-related information has become available to any practitioner with an Internet link. Wireless Internet access means that pavement practitioners now have access to a reference source of pavement-related information wherever they can find access to the Internet, ensuring that correct and applicable information can be used in pavement-related decisions. The ready access to international information on pavement engineering also allows the industry to appreciate the differences between countries as far as pavement engineering techniques and practices are concerned, and promotes innovation in the industry, since practitioners can start to evaluate their own approaches to pavement engineering.

Pavement Interactive can be a powerful knowledge transfer tool. Although efforts related to it are not directly dedicated to pushing the frontiers of knowledge regarding pavements, they *are* directly related to improving the reach and influence of such efforts, as well as to providing a tool to help improve knowledge within and outside the industry.

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REFERENCES

The list of references is available from the editor. □