IMPLEMENTATION OF INTERACTIVE WEB-BASED TRAINING TOOLS IN PAVEMENT ENGINEERING

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ABSTRACT
South Africa experiences a dire shortage of technically skilled roads professionals to deal with the construction, maintenance and management of its extensive road network. Training of the available technical staff in roads-specific areas is vital to ensure that the investment in road infrastructure is not lost due to a lack of insight and knowledge. A range of available training avenues should be evaluated in order to address the required training of the available technical staff. One such an avenue uses interactive web-based training. Pavement Interactive (http://pavementinteractive.org) is an online pavement community built on an open-source wiki platform where users can create, edit, browse and search site content with just a computer, web browser and Internet connection. It contains over 500 web pages and has logged over 1 million pageviews in 2.5 years of existence. Pavement Interactive is an ongoing experiment in coupling a participatory application with a unique dataset to improve worldwide knowledge transfer. Observations of use indicate: (1) primary use as a ready-reference and learning tool, (2) collaboration functions are possible but not extensively used, (3) substantial quality content attracts users, (3) participation drives success, (4) a majority of effort should be dedicated to content creation and participation, and (5) there should be a means to maintain currency for such websites beyond the funded development phase. This paper evaluates the potential for application of Pavement Interactive in order to partly address the skills shortage in the roads arena in South Africa.

INTRODUCTION AND PROBLEM STATEMENT
South Africa is experiencing a dire lack of technically trained technicians, technologists and engineers to cope with the demand that the expanding roads network place on construction, maintenance and management to keep the network in a serviceable condition. Investigations indicate that the majority of municipalities in SA do not have technically trained technologists or engineers responsible for roads employed. In provincial transport departments the situation is similar, with a lack of adequate technical capacity. The lack of appropriate technical knowledge hampers the adequate attention required to keep this costly infrastructure in a serviceable condition. This process leads to an unacceptable deterioration of the condition of the infrastructure (Lawless, 2005; 2007).

The only feasible method to counter this potential deterioration of infrastructure is to invest in the technical knowledge of the staff responsible for the maintenance and management of the road infrastructure. Not many tertiary institutions offer pavement engineering as a specialist field of training, and therefore the information that most engineers have on 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 shear number of students that require this type of training, together with the long distances that students often have to travel to attend formal training and education in pavement engineering, typically makes it non-feasible for the majority of students and practitioners in the developing world.

At the Tshwane University of Technology (TUT) B.Tech pavement engineering and asphalt design classes typically range in the region of 60 to 100 students per semester, the University of Pretoria

(UP) trains around 93 students per year in the honours subjects of pavement design, rehabilitation design, asphalt design and stabilisation (Visser, 2009) and the Asphalt Academy (ASAC) typically reach in excess of 650 students per year with their pavement related courses (Sampson, 2007). A reasonable component of these students originates from provinces far from the institution and the rest of Africa. However, this is still a drop in the ocean regarding the actual need for technically trained technical staff to fulfil the maintenance and management roles in South Africa. Further, tertiary training takes up time from the already small pool of technical people, causing only a small number of these technical people to actually become involved in tertiary studies. A lack of previous higher education often adds to this lack of tertiary students in the transport environment.

Although self-paced learning will typically not take the place of formal lecturing and coursework, it does provide for 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. A novel approach to addressing this training requirement can be attained through the appropriate use of Web 2.0 technologies, through which interactive web-based training can take place with students located at their offices or homes and in their own time. In this paper the potential application of the Pavement Interactive wiki in training South African and southern African roads professionals in various aspects of road construction, maintenance and management is discussed.

BACKGROUND TO PAVEMENT INTERACTIVE

Web 2.0 background

"Web 2.0" is a general term used to describe the latest generation of the World Wide Web that focuses on collaboration and information sharing rather than just the placement of information online. Web 2.0 has driven success for companies such as Google, Amazon, Wikipedia, Facebook and Flikr. Pavement Interactive (http://pavementinteractive.org) is an ongoing experiment in leveraging Web 2.0 ideas to improve pavement knowledge transfer on a worldwide basis. Specifically, Pavement Interactive is an online pavement community built on an open-source wiki platform. Pavement Interactive went live online in September 2006 and as of March 2009 has logged over 1 million pageviews and 20 000 edits. It contains over 500 web pages worth of information and is viewed worldwide on a daily basis.

Pavement Interactive is a highly active website on a worldwide basis that comes close to realising several, but not all, Web 2.0 fundamental ideas. Importantly, as the Internet has fast become the primary means of information and data transfer among disparate communities in the world, it is important to understand how such a medium can be effectively used for knowledge transfer within the pavement community.

Knowledge transfer over the Web

Knowledge transfer refers to "…activities causing the flow of knowledge from one person, group, or organisation to another." (Harder and Benke, 2005). As opposed to "information transfer", "knowledge transfer" implies that some knowledge is gained by the receiver. Such activities are essential to education and training within and external to the pavement industry, and causing innovation to be translated into practice. Knowledge transfer activity "design" refers to the combination of media and method employed. Thus, an instruction video, classroom discussion and online training are all different knowledge transfer activity designs.

Most research suggests the chief barriers to knowledge transfer are time and money (Mericka, 1992; O'Shaughnessy, 1992; Muench and Mahoney, 2004). Specifically, work schedules are often full and cannot accommodate time in the middle of the day for a scheduled training session. Further, as budgets get smaller, all industries are looking for ways to reduce overall expenditures, which often includes cuts in training budgets. Often, distances to locations where training is presented also hinders attendance. This situation suggests that there may be a growing demand for quality information capable of being delivered at the convenience of the user. This idea of instantaneous training when it is needed is sometimes referred to as "just-in-time training." Often, the media of choice for just-in-time training is online. The American Society for Training and

Development (ASTD) reports that e-learning in 2007 constituted 32.6 per cent of corporate learning hours (Paradise 2008). Traditional knowledge transfer designs are less capable of meeting just-in-time needs.

Web 2.0 essential ideas

While the idea of migrating print information to the Web ("Web 1.0") represents a significant advancement over static print media, the Web is capable of more than static electronic displays of information. "Web 2.0" characterises the Web as a platform spanning all connected devices that delivers 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 (O'Reilly 2005). Web 2.0 successes include Google, Flikr, Facebook, Wikipedia and blogs. 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*. Unique, rich and useful content drives users to the website.
2. *Service and not product***.** Provide a service instead of a packaged product that must be installed and upgraded.
3. *Users as co-developers*. Add new features often and see if users like them. Users will understand they are part of the development process and provide the most valuable feedback.
4. *Harness collective intelligence*. A service that harnesses the collective activity and knowledge of all its users can grow based on user input and can direct efforts based on user preferences. This provides low-cost growth and properly focused improvements.
5. *Serve the individual user rather than the large organisation*. The bulk of users for a pavement knowledge transfer service are likely to be from many disparate and often small organisations (i.e. local municipalities in South and southern Africa) with different standards and purposes. Catering to these users creates a service that is relevant to all rather than a handful of large organisations.
6. *Software usable by multiple devices*. Personal computers are not the only devices accessing the Web. Services should be designed for all Web-enabled devices so that user groups are not intentionally excluded. This includes cellphones, netbooks, notebooks and internet cafes.
7. *Simple applications and development models*. These are more likely to be used and reused. Complex applications and/or development restrict users to those with the motivation and ability to overcome such complexity.

Web 2.0 pavement community efforts to date

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. Table 1 lists participation rates of the most popular of these community websites.

Table 1: Participation in pavement-related community websites as of 10 March 2009.

Title	Total Posts	Years Since Inception	Posts/Day
Blogs			
Green Highways Partnership (GHP) "U"	3	1.32	0.01
Rocky Mountain Asphalt	2	1.58	0.00
Concrete Pavement Surface Characteristics Track (CPSCT)	16	1.51	0.03
Newsgroups			
Pavemanpro.com	134	1.15	0.32
TRB WebBoard			
AFD00 Pavement Management	1	7.98	0.00
AFD10 Pavement Management Systems	38	8.26	0.01
AFD40 Full Scale Accelerated Pavement Testing	3	6.12	0.00
AFD70 Pavement Rehabilitation	58	7.08	0.02
FHWA Communities of Practice - Highway Community Exchange			
NCHRP 1-37A Pavement Design Guide	279	4.60	0.17
Wikis			
Pavemanpro.com	19	1.15	0.05
Pavement Interactive	20 806	2.52	22.59

Pavement Interactive (http://pavementinteractive.org) 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), a pooled fund study consisting of Departments of Transportation from Washington, California, Minnesota, Texas, Illinois, Idaho, Kansas, Maryland, Florida and the Federal Highway Administration (FHWA). Pavement Interactive seeks to leverage Web 2.0 ideas to create a pavement knowledge transfer resource. Specifically, Pavement Interactive is a wiki, which is a collection of web pages that allow any user to contribute or modify content using a simplified markup language. Because of their open nature and simple structure, wikis are often used as the principal software in collaborative and community websites.

Pavement Interactive Architecture

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. The following types of information are accessible on Pavement Interactive:

- *Articles.* The fundamental information unit in a wiki, an article is a webpage where content on a particular topic resides. It can contain text, pictures, animations and video for a particular topic.
- *Categories.* Each article belongs to one or more categories, which can serve as filters for browsing. Articles are accessible from many category pages, which enhance organisational options and browsing.
- *Portals.* A portal is a page that serves as one particular viewpoint of the information in Pavement Interactive. Content specified by the portal owner can be referenced and viewed through a user-generated table-of-contents or directory within the portal.
- *Namespaces.* A namespace allows for more than one article on the same topic providing the capability to have multiple viewpoints or special discussions on a topic.

Some of the key features of Pavement Interactive include the following:

- *Open architecture.* Pavement Interactive was set up with an open architecture where anyone can sign up for an account and contribute to the knowledge base. Security provisions were put in place to ensure that researched articles and information specific to a group or member could only be edited by approved contributors.
- *Versioning.* The ability exists to capture each revision of an article. This has the effect of maintaining a large historical archive of all article versions and provides a straightforward mechanism for undoing articles edits that may be deemed incorrect or inappropriate.
- *Support for multimedia.* Digital documents, images and animations can be uploaded to Pavement Interactive and embedded in articles.
- *Mapping support.* Maps can be created within an article using an embedded Google Maps application.
- *Notification.* To help engage the community and alert readers and authors of updates there are a series of tools incorporated into Pavement Interactive to provide notification to users (i.e. RSS (Really Simple Syndication), news feeds, e-mail notifications and discussion pages that provide a forum for discussing potential article updates).

Pavement Interactive content origins

At its inception, Pavement Interactive was populated with substantial content that came from a 20-year development effort that started as a manual of local, national and international pavement practice for the Washington State Department of Transportation (WSDOT). Each development step substantially increased sophistication and reach of the basic content. Major development products can be summarised as follows (refer to Table 2):

1989-1995: paper-based product

The original paper-based product was developed to improve reach and understanding of pavements within WSDOT. This product became an official WSDOT publication immediately following development and remains so today. The drawbacks to the paper-oriented product were updates/revisions and media costs.

1995-2001: electronic .pdf CD-based product

In 1995 the original paper-based product was converted to a Portable Documents Format (PDF) so that it could be distributed on CD. Content was updated and colour photographs added. This version increased the number of users by about a factor of 10 and reduced distribution costs to about 10 per cent of the paper-based product level. Actual production/copying costs are estimated to have dropped by a factor of 100.

2001-2005: electronic HTML CD-based products

In 2000 the growing body of knowledge underwent a major overhaul. It was moved into HyperText Markup Language (HTML), received a new interactive interface, more media were added and the educational side was made more prominent with the inclusion of learning objectives and quizzes. Six separate CD-based versions were produced for different clients. Evidence from learning assessments (Muench, 2004) showed learning occurring and evidence showed better-than-expected reach. CD versions were extensively used in at least 7 universities. It was originally thought that production using desktop HTML editors would allow customisation and frequent updating by sponsor organisations but neither happened. Only one version received a minor update from a client organisation as client organisations simply did not have trained staff or available time to learn HTML editing software, update the CD and publish it. Thus, the CD versions were essentially static.

2005-present: CMS Web-based product

In 2005 updates and customisation shortcomings were addressed by producing a CD version using a web-based Content Management System (CMS). A CMS is software that creates an online workflow for content creation, editing and publishing. User permissions are set up so that only certain users have authority to edit and publish. Most major news websites run on CMS software. The CMS version was abandoned after about four months of development for three reasons. First, the workflow management and control system set up for article publishing was still too complex to

be used by a typical time-constrained practitioner. Second, the internal structure of the CMS required articles to reside in fixed sections. Third, the rising popularity of social networking websites such as Facebook seemed to show promise in allowing direct user-to-user interactions. None of these ideas could be accommodated by the CMS so it was abandoned. The current wiki version of Pavement Interactive was launched in September 2006.

Usage

General usage

This section refers to Google Analytics statistics for the Pavement Interactive website between 10 March 2008 and 10 March 2009, one year of the most recent activity. The one year monitored period has seen about 75 000 unique visitors and currently averages about 3 000 unique visitors/week. This has been trending steadily up from an average of 808 unique visitors/week in March 2008. The majority of visits have come from the U.S. (70 per cent) with 75 countries with over 100 logged visits including Canada (7.7 per cent visits), Malaysia (6.7 per cent visits), South Africa (1 per cent visits) and others. Visits from southern Africa accounted for 20 per cent of all African visits to Pavement Interactive during this period.

"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 pageviews and 20 000 page edits. There are 565 registered users, of which 56 have contributed (10 per cent). There appear to be three major groups of contributors. First, a core group of four users (0.7 per cent) from the University of Washington account for about 10 000 edits (about 50 per cent). Second, a group of students resulting from class offerings account for about 6 000 edits (about 30 per cent) and finally, a group of PTC members account for about 700 edits (about 3.5 per cent).

Table 2. 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 will likely be different. Also, development of each version was predicated on the previous version content being updated and reused.

The 90-9-1 rule

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 (Nielson, 2006). This has often been stated as the 90-9-1 rule where 90 per cent of users merely view content, 9 per cent contribute content in some fashion, and 1 per cent account for most contributions (Nielson, 2006; 90-9-1 Theory 2008). Swartz (2006) has demonstrated, however, that a majority of edits that add substantial new content to Wikipedia

seem to come from infrequent contributors while most edits (those that come from the 1 per cent) were typically small changes to format. It appears Pavement Interactive tends to follow the 90-9-1 rule rather well.

Information quality

As Pavement Interactive has evolved there have been two major concerns about content quality. These are content dominance by a small group of contributors, and inappropriate content or vandalism. Content created in earlier versions and moved over to populate Pavement Interactive has been verified by independent external review. However, new articles created in Pavement Interactive are typically only reviewed by the authors of this article. To date, this has not been a concern but it could present future problems as our interests may be deemed insufficiently 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 lead 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 directly use in instruction. Encouraging efforts with South Africa are currently underway at the Council for Scientific and Industrial Research (CSIR) and the University of Pretoria for making major contributions.

A second concern is that since virtually anyone can register and contribute content, quality could be degraded by promotional content, inaccurate content from novices, and malicious content ("vandalism"). To date, most users are knowledgeable and courteous, and there is probably not enough Internet exposure to attract vandalism. However, the site does track all article revisions and users. In the case of vandalism, articles can be easily rolled back to their original form and users can be restricted by administrators.

Future and Related Products/Features

Development on Pavement Interactive and related products continues. Focus in the next year will centre on exploratory work with:

- *Mobile device support.* Data phone devices are becoming more common business tools. Their use could substantially increase reach by allowing access from anywhere with mobile phone coverage.
- *Data storage and integration.* As technology continues to evolve the ability to archive Pavement Interactive data in more meaningful ways will grow. For instance, photos, test results, video, Pavement Interactive articles and more could be spatially referenced (as photos can be on sites such as Picasa and Flikr) and integrated to provide a web-based map of relevant project information and associated in-depth articles. A beta test of this, called Pavement Interactive Maps, is underway at: *http://maps.pavementinteractive.org*.

TYPICAL APPLICATIONS AND USES

The previously discussed information can help assess how Pavement Interactive has fared since its inception in terms of how it tends to be used, to what extent does it successfully incorporates the seven Web 2.0 essential ideas, and what this infers for future Web 2.0 efforts in pavement knowledge transfer.

Use

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. There is some evidence, although most of it is indirect, that Pavement Interactive is being used by college students.

Ready reference and learning tool

Google Analytics data suggest Pavement Interactive is being used primarily as a ready reference and learning tool. This use pattern suggests that few users are likely to take advantage of the full

suite of Pavement Interactive services. In general, the vast majority of the users tend to access Pavement Interactive by going directly from a search engine result to an article. Comparatively few (4.35 per cent of pageviews) see the home page. This implies that most users may be unaware of other Pavement Interactive features. Based on the average page viewing time (1 minute, 8 seconds) most users do not access a page long enough to read its entire content. 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 only looking for a small amount of information but tend to demand it in a timely manner. Users coming from university and 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 pageviews per visit (7 to 10 page views) than the average (4.75 pageviews per visit). This suggests that these users are engaging in multiple topics in their visits and perhaps using Pavement Interactive as a training tool.

University textbook

Pavement Interactive is used as the primary reference for four courses at the University of Washington (UW) (two online classes, one in-person undergraduate class and one in-person graduate class). It is also used as a reference source in pavement engineering courses at TUT and UP.

Course website

Pavement Interactive is used as the primary course website for one graduate class at UW. While it has been successful in this use, the lack of dedicated Pavement Interactive editors outside UW seems to be reflected here as there are no other course presences on Pavement Interactive. Essentially, this course website functions as a proof-of-concept and is not a typical use.

Online collaboration

The "groups" area was designed as place for collaborations and working groups to communicate. There are 18 entries in the "Groups" area of Pavement Interactive consisting of three courses, five working groups, nine committees and one organisation. With the exception of one course (CEE 597) and one working group (Greenroads), most of these groups are non-functional with only an initial post created to form the group and no significant discussions.

Web 2.0 essential ideas

An assessment of how well Pavement Interactive has been able to incorporate the seven Web 2.0 essential ideas discussed earlier indicates the following:

1. *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, for the most part, content has been reviewed by subject matter experts. This idea has been fully incorporated.
2. *Service and not product***.** Early attempts at electronic delivery of Pavement Interactive content were essentially products. This product focus made the content static and isolated from any user interaction. The wiki format used by Pavement Interactive has attempted to move this content into a service model, however the collaborative uses have not been popular and edits outside a small core group of editors have been minimal. It appears that Pavement Interactive is a service that accesses the 500 or so content articles but has not, to date, generated significant online collaboration.
3. *Users as co-developers*. New features are added as they are developed. There is no set version release schedule. Most new features are incremental improvements, however, the addition of Pavement Interactive Maps is a substantial new direction. Over 900 000 pageviews in 2.5 years of existence suggests that for much of the pavement community Pavement Interactive is not being treated as a research effort.
4. *Harness collective intelligence*. The wiki platform on which Pavement Interactive runs provides a straightforward avenue for anyone to contribute to or write new articles. As previously discussed, participation has been limited to a few main contributors. While broader participation is desired, it

appears that small percentage of the registered users making most of the edits is an established pattern of behaviour in wikis. Therefore, although it is capable of incorporating content from any user, Pavement Interactive has yet to incorporate this idea.

5. *Serve the individual user rather than the large organisation*. Most articles in Pavement Interactive are not organisation specific. Organisations can create their own pages and write organisation specific information if they choose. To date, this has been done sparingly and does not seem to contribute substantially to the body of knowledge in Pavement Interactive. Therefore, this idea has been fully incorporated however there is room to accommodate both the individual user and the large organisation.

6. *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.

7. *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 markup 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 markup shorthand rather that 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.

Inferences based on observations and assessments

Quality content is the most important contribution

Prior to Pavement Interactive, previous efforts by the developers were products that were designed to be broadly applicable in the U.S. However, most versions were created because a specific organisation wanted a manual that contained their own local practices in addition to this broad information. 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 like Pavement Interactive is the writing of quality technical content.

Success or failure of community sites is driven by participation

Participation by the online community determines a site's success or failure. Precursors to Pavement Interactive were focused on the enabling technologies with the belief that there was a latent desire to participate. However, participation overwhelmingly came in the form of reading rather than providing or updating content. For a community website such as Pavement Interactive, editing participation is essential to maintain information current and relevant over the long term. Therefore, over the last two years, the development team has focused more effort on encouraging participation. Based on this experience and observations of other pavement-related participatory websites it appears that community website efforts that do not directly address participation are not likely to succeed in the long term.

Web 2.0 must live beyond their funding time frame

One of Pavement Interactive's strengths is that it can be continually updated for modest cost. Theoretically, this allows the body of knowledge to stay current over time. Examples of this model are online community-based sites such as the Microsoft Developer Network and Wikipedia. While participation plays perhaps the dominant role in updates, funding also plays a key role. Estimates of software maintenance and support costs in the literature vary from about 40 to 90 per cent depending upon assumptions (Boehm, 1981; Mukhija, 2003), although there is little published data to substantiate these. To keep these costs down, Pavement Interactive leverages the open source nature of Mediawiki to keep maintenance costs down (Capra et al, 2007). Even so, installations, commercial server costs, feature additions and participation promotion will still require funding. Typical research contracts in the pavement field provide funding over a finite period of time (typically six months to several years), beyond which no money is available for continuing updates or maintenance. This funding model will not work for Web 2.0 services. To support the website's

continued growth the authors and the PTC are exploring alternatives to allow Pavement Interactive to stay current beyond the end of the PTC contract. Although no decision has been made, potential options include:

- Extend the PTC contract. This is only a temporary fix because it does not address the problem of a finite contract period.
- Create a sustainable business model. This would contain three key components. An oversight group to govern strategy and quality, revenue great enough to maintain Pavement Interactive online, and day-to-day maintenance by a commercial entity. Oversight group candidates could include a specially selected governing committee from organisations such as the American Association of Highway and Transportation Officials (AASHTO) or the FHWA. There is some precedent in doing this for products like DARWin and the new Mechanistic-Empirical Design Guide (MEPDG) software. Models for revenue include: advertising (e.g., Google, Yahoo targeted advertising), donations (e.g., Wikipedia), public sponsorship or some combination thereof. Commercial maintenance of Pavement Interactive is likely because typical public organisations like universities and DOTs are not organised to provide proper maintenance for a website like Pavement Interactive over the long term.

SA SPECIFIC APPLICATIONS

Introduction

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 with a focus on specific local pavement issues (such as specific problem soils or environmental conditions). Through this process the hope exists that eventually an online resource with both global and local information will be available. Through application of Portals selected articles can then be combined for specific use of selected countries, regions or agencies. In an attempt to start such a southern African focus with information of a local interest and focus, pavement related topics that are unique to SA have been identified and are currently being prepared for and added to Pavement Interactive in the CSIR / SA portal. The focus is on information that needs to be added to ensure that SA practices are clearly described and referenced. An initial list of potential topics was developed (Table 3) and then investigated in detail to determine where information was available that could add value to the wiki.

Table 3: List of typical SA pavement topics to be added to PI wiki.

DCP balance concept
G1 base layers
Heavy Vehicle Simulator / Accelerated Pavement Testing
Labour intensive construction
SA Pavement Design Method
Seal design
Stabilised material design and analysis
Statistics for pavement engineers
Thin concrete layers
Unsealed roads

Until March 2009 the following information have already been added to the wiki:

- General CSIR information (contained in the website link);
- Design and construction of surfacing seals - TRH13 (in terms of a summary of the contents of the document as well as a link for downloading the document);
- HVS related background information (originating from the SATC 2007 workshop on HVS technology, including articles on environmental effects, typical applications, loading, measurements and test planning. Reference is also made to the HVS manual), and
- International HVS locations.

Information on the following topics are currently being sourced and collated to add the information to the wiki during 2009:

- G1 base layers;
- SAPDM, and
- DCP pavement balance concept.

A CSIR sponsor portal was added to the PI wiki and it was populated with information as part of this project. The current CSIR portal contains links to the following information:

- CSIR website, APT background, brochures and Knowledge Dissemination Portal;
- Pavement Research Advisory Committee information;
- Links to the Sabita, Asphalt Academy and C&CI Concrete pavement design software websites.

Evaluate the effectiveness of Pavement Interactive in SA

Information from the PI wiki have been included in the reading material and class notes or the 2008 TUT B.Tech courses on pavement design and asphalt design, as well as the 2009 UP honours course in pavement design and 2nd year pavement design. As the 2009 courses are still ongoing at the time of writing this report, the feedback from students is still limited. For the 2008 courses it was found that especially the interactive articles and demonstrations allowed students to understand some concepts better. During the discussions on potential uses and required improvements and additional information required the following areas were identified.

Guidelines for prescribed content for potential users

A first-time user of the PI wiki may be confused regarding the most appropriate place to start with the reference material, and also the logical approach to follow through the reference material. A number of potential routes with information that may be relevant to specific practitioners have been devised and are provided as a first-time user's guide in Table 4. These can be added to a specific Portal to enable potential users with specific requirements to find their way around the wiki.

Table 4: Guidance for routes through PI wiki Core Modules for different focus groups.

	Core modules													
Focus group		**Pavement history**	**Pavement types**	**Materials**	**Design parameters**	**Mix design**	**Testing**	**Structural design**	**Construction**	**QC & QA**	**Specifications**	**Pavement evaluation**	**Rehabilitation**	**Maintenance**	**Pavement management**
	General pavement engineering	X	X		X			X		X	X				X
	Maintenance and rehabilitation		X	X	X		X	X		X	X	X	X	X	X
	Design		X	X	X	X	X	X			X				
	Construction					X	X		X	X	X				
	Management systems		X							X		X		X	X
	Laboratory testing			X	X	X	X			X	X				
	Field evaluation			X	X				X	X	X	X			
	Tertiary education (TE)														
	TE – Materials	X	X	X		X	X			X					
	TE – Design	X	X	X	X			X	X		X				
	TE – M&R	X	X							X		X	X	X	X
	General public	X	X												

Broadband connectivity in SA

The issue around access to the web for typical SA users is important to address, as a lack of suitable access will hinder the application of the site. In general, SA broadband services are much more expensive than international costs. However, these costs tend to decrease, and over time the physical cost of the service should be comparable to international costs. Of more importance is the access to adequate broadband services. In SA, the majority of the country is covered through broadband access of some kind, either through fixed lines or mobile services.

The specific pages on Pavement Interactive are typically less than 100kb in size, with the majority even less than 50kb. Current (April 2009) ADSL broadband costs in SA starts at around R 49/Gb, while wireless broadband costs start at around R 200/Gb. This translates to a typical cost of less than R 0.049 (broadband) or R 0.2 (wireless) per article for access to Pavement Interactive in SA. Viewing all of the current 511 articles in Pavement Interactive should thus cost less than R 25.04 (broadband) or R 102.20 (wireless).

CONTRIBUTION OF PAVEMENT INTERACTIVE TO INDUSTRY AND FUTURE DEVELOPMENTS

Contribution to industry

In order for Pavement Interactive to succeed in its role as training tool, it is important that it actually reach the intended market. The main contribution to industry is that a central on-line link to a host of pavement related information became available to any practitioner with an internet link. With the advent of wireless internet access, the availability of this resource means that pavement practitioners can 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 access to international information on pavement engineering also allows industry to appreciate the differences in pavement engineering techniques and practices and allows for innovation in the industry where practitioners can start to evaluate there own approach towards pavement engineering based on this available international information.

Pavement Interactive is an ongoing experiment in leveraging Web 2.0 ideas to create an effective knowledge transfer system. Pavement Interactive has been active online since September 2006 and has logged over 1 million pageviews and 20 000 edits over its 2.5 years of existence. Since January 2008 Pavement Interactive traffic has been tracked using Google Analytics. This effort has show a number of interesting facts and trends:

Extensive use

Use is worldwide and growing. This may be because the majority of pavement information sought on a worldwide basis is fairly simple in nature, which makes the constraining resources time and access to credible information rather depth and specificity. Comparable to other websites tracked by Google Analytics metrics for Pavement Interactive compare favourably with typical values expected for commercial websites, which indicate that the site is being used in comparable fashion.

Limited user contribution to content

Pavement Interactive tends to follow the 90-9-1 rules rather well. Most users are viewers only with a small subset at UW being active contributors responsible for over half the total website edits. Because of this, research efforts have focused on generating new content and forging relationships that might result in content creation.

Ready reference and learning tool

Website traffic patterns indicate users typically enter Pavement Interactive directly from search engine results and usually bypass the home page. Pages are likely scanned rather than fully read. Use originating from DOTs and Universities shows more pageviews per visit and lower bounce rates indicating that that more in-depth use is occurring. Collaboration functions are possible but not extensively used. Wikis were invented as collaborative websites. Although Pavement

Interactive hosts some collaborative efforts there are not many and most are not active. Users do not appear to value Pavement Interactive's collaborative service.

Requirements for more efficient knowledge transfer

Based on the observations on Pavement Interactive usage, several conclusions can be made about how to design and implement Web 2.0 websites for knowledge transfer.

- Substantial quality content attracts users. While there may be interest in current media platforms that are capable of improving potential reach, users will return only if the content is satisfactory.
- Participation drives success. For community websites, success can be measured in participation. At the simplest level, this can be measured in pageviews or unique visitors. A more robust and sustainable website, however, should have substantial participation in content creation.
- A majority of effort should be dedicated to content creation and participation. Given the previous two rules, this follows naturally. A rough rule-of-thumb might be 60 to 70 per cent of the effort should focus on content and participation.
- There should be a means to maintain currency beyond development. Most development efforts are centred on relatively short term (1 to 3 years) contracts. While this model continues to work well for many efforts, it leaves no mechanism for information maintenance and update. Novell mechanisms should be explored including sustainable business models that rely in whole or in part on private industry.

In closing, Pavement Interactive can be a powerful knowledge transfer tool. While efforts related to Pavement Interactive are not directly dedicated to pushing the frontiers of knowledge in pavements, they are directly related to improving the reach and influence of such efforts as well as providing a tool to help improve knowledge within and external to the industry.

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