Hydrol. Earth Syst. Sci. Discuss., 9, 2541–2567, 2012
www.hydrol-earth-syst-sci-discuss.net/9/2541/2012/
doi:10.5194/hessd-9-2541-2012

Hydrology and Earth System Sciences Discussions

Web 2.0 collaboration tools to support student research in hydrology – an opinion

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Received: 23 January 2012 – Accepted: 16 February 2012 – Published: 27 February 2012

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Published by Copernicus Publications on behalf of the European Geosciences Union.

Abstract

A growing body of evidence suggests that it is unwise to make the a-priori assumption that university students are ready and eager to embrace modern online technologies employed to enhance the educational experience. We present an opinion on employing Wiki, a popular Web 2.0 technology, in small student groups, based on a case-study of using it customized as a personal learning environment (PLE) for supporting thesis research in hydrology. Since inception in 2006 the system presented has proven to facilitate knowledge construction and peer-communication within and across groups of students of different academic years and to stimulate learning. Being an open ended and egalitarian system, it was a minimal burden to maintain, as all students became content authors and shared responsibility. A number of unintended uses of the system were also observed, like using it as a backup medium and mobile storage. We attribute the success and sustainability of the proposed web 2.0-based approach to the fact that the efforts were not limited to the application of the technology, but comprised the creation of a supporting environment with educational activities organized around it. We propose that Wiki-based PLEs are much more suitable than traditional learning management systems for supporting non-classroom education activities like thesis research in hydrology.

1 Introduction

With the rapid-phased entry of information and communications technology (ICT) into our lives, spearheaded by world wide web (WWW), the way we communicate, entertain and educate ourselves has changed dramatically over the last two decades. Educators assumed that the embracing of ICT by general public, particularly the young, has profound impacts on how the process of learning happens in formal environments like universities. Prensky (2001), in his much-commented article, proposes: "the differences between our Digital Native students and their Digital Immigrant teachers lie at

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the root of a great many of today's educational problems". In the early stages of the "ICT in education" debate, it was claimed that today's university students are "... active experiential learners, proficient in multitasking, and dependent on communications technologies for accessing information and for interacting with others" (Oblinger and Oblinger, 2005; Bennett et al., 2008). However, many educators have questioned the validity of this assumption (Bayne and Ross, 2007; Bennett et al., 2008, among others). For example, the fact that the age group of 16–18 having being the dominant users of social networking does not necessarily translate into a more technology focused learning style at university stage (JISC, 2007).

In this context, we believe that ICT and WWW technology, particularly participatory web (Web 2.0), has to be employed in education with caution, without pre-conceived assumptions on fit-for-use in a particular domain and with an open empirical approach. In this paper, we present a case-study during which we applied Web 2.0 technologies as a Personal Learning Environment (PLE) to foster collaboration and learning in students engaged in master's level research in hydrology. Particularly compared with traditional Learning Management Systems (LMS), we discuss the nature of the approach, its challenges, proven benefits and the issues we encountered during its implementation over a five year period (2006–2011). We also extrapolate the findings to suggest other uses of the tested system in education.

2 The problem

2.1 Thesis research in hydrology at UNESCO-IHE

Study on water is a multi-disciplinary problem: it has long been accepted that the science on which responses to present and future global water problems must be based does not fall within the purview of a single discipline but rather is multidisciplinary and interdisciplinary (Jury and Vaux, 2005). Most of UNESCO-IHE thesis projects focus on problems that are of immediate practical importance and impact on human societies

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and the environment in a multitude of ways. This nature of our work challenges the students to venture into new areas not necessarily covered during coursework and to master them, sometimes even before starting the real application work. Taken along with the challenge of finishing the thesis project within the standard six months period, this imparts pressure both on the student and the supervisor and demands innovative didactic approaches.

Every year between 150 and 200 students enter UNESCO-IHE as candidates of water related masters degrees. This is arguably the largest post-graduate program on hydrology (in its broad sense) in the world. Students generally attend coursework for a year and conduct research leading to a master's thesis during a period of six months. While the two phases are integral parts of the same degree programme, the skills needed from the students as well as approaches demanded from the faculty are quite different in each. A need to foster improved supervisory practices in thesis research has been identified in many graduate schools in the world (Acker et al., 1994; Aspland, 1999) and UNESCO-IHE also continues to strive for improving the effectiveness of graduate thesis supervision process. The background of our students (see below) makes it important to pay even more attention to the process of conducting and supervising thesis research.

Majority of students of UNESCO-IHE are mid-career professionals who have been working in the sector (industry, government, academia, etc.) for at least two years (often much longer) after their bachelor's degree. Apart from an undergraduate thesis in some cases, the master's thesis at UNESCO-IHE is their first encounter with scientific research. The 'distance' of memory of university days also makes it difficult for some students to re-adjust to a life of formal learning and research – while this problem is often felt during the coursework, it is manifests more severely during the thesis period, when the students work on their own individual research project. Wide variations in competency levels in supporting skills like computer literacy (e.g. programming) within a single batch of students are often noted. Identifying these, various preparatory activities are being routinely organised (e.g. classes on literature search, computer

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programming, technical writing, etc.). However, the fact remains that we need and want to continuously and vigorously improve the process of thesis supervision.

2.2 A Theory Y environment

In sixties, management psychologist McGregor (1960) identified two styles of management he coined as, Theory X: which assumed that the authorities has to actively direct the elements of productive enterprise without which the employees would be passive and even resistant to organizational change and Theory Y: which assume the emploies seek and accept responsibility and the satisfaction of doing a good job is a strong motivation. Biggs and Tang (1999) proposed that the idea of Theory X and Theory Y climates transfer readily into the classroom. In this context Theory Y implies that students do their work best when given freedom and space to use their own judgement and that the bureaucratisation of the classroom is counterproductive for effective learning. This view gained popularity among educators during the last decade. Theory Y approach has been shown to be quite successful in team building where individuals work is related and dependent upon their peers (e.g. Software engineering; Birkinshaw and Crainer, 2008). A brief look at the diverse nature of problems addressed in thesis research in hydrology at UNESCO-IHE and the inter-linkages among research problems, approaches and techniques within a group of students, suggest that it is a "Theory Y" environment that is desirable (even more so than in the classroom education) because such an atmosphere could stimulate both individual research and teamwork.

2.3 What type of web-based system is needed for a Theory Y environment?

The varied nature of thesis projects and needed skill sets to achieve them, make their activities, elements, milestones and goals quite unique and non-generic. We wanted to use web-based tools to activate peer-learning, which has been proven to be one of the most effective strategy in education (Biggs an Tang, 1999, p. 96, 118–119 pp.). The

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basic requirements of the web-based system we envisioned for supporting a Theory Y learning Environment were:

- Could hold most (if not all) documentation (including multimedia content) related to each thesis project.
- Beginner friendly scheme where (accidental) destruction of information is virtually impossible.
- Highest possible degree of autonomy for the user.
- Controlled-entry to the system (Not open to public) so that users feel comfortable having "work on progress" on it.
- Unrestricted access to all work (Documents, computer programs, data, etc.) by peers in the group for the purposes of evaluating, learning from, and adopting for new purposes.
- A good search system and linking scheme so that the students can construct knowledge based on existing knowledge (Biggs and Tang, 1999, 92–93 pp.)

Further we wanted to promote the following principles:

- Collaboration and team work which is very important for good research outcomes as well as an antidote to the inevitable stress of rapid-phased scientific research.
- Healthy competition among students to excel in their work.
- Users not being restricted in the way they express themselves on the system – so that their creativity is not restrained.

We already had access to two LMS systems, namely the in-house "i-learning environment", which was the primary LMS of UNESCO-IHE at that time and a non-production Moodle installation used for experimentation. One of the challenges of adopting LMS

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for our purpose was to allow for the necessary freedom within the system. By necessity LMS are vertically integrated systems whose collaborative functions are secondary (e.g. Moodle has ability to incorporate wikis within a course). We decided to look beyond LMS.

2.4 Web 2.0

The term Web 2.0 is an example of name preceding the definition: the term Web 2.0 started appearing in online sources largely since 2006, but even a year later, there was a large disagreement over what it exactly meant (O'Reilly, 2007). Tim-Barnes Lee, the inventor of WWW called is just a "piece of jargon", on the grounds that what it tried to achieve was exactly the initial objective of the WWW – a collaborative medium where everyone could "read and write" (Laningham, 2006). However, today the term "Web 2.0" represents an approach that is user-centric, collaborative, decentralised and dynamic in knowledge building and sharing.

Web 2.0 is widely used in education today. Conole and Alevizou (2010) provides a detailed review of the practice in the Higher Education sector of the UK. There are numerous examples of applications of Web 2.0 in different fields of higher education (Luo, 2010; Kim, 2010, among others), each of which used one or several of the multitude of Web 2.0 features. For example Luo (2010) focuses on the power of Wiki systems on creating validated contents, while Cochrane and Bateman (2010), describes the use of rich-content (e.g. multimedia) in mobile media like Smart phones.

In the context of the current article, the focus has been on a few features of Web 2.0 namely, user centeredness, lack of hierarchy, dynamism and informal peer-review.

2.5 LMS and Web 2.0

Today, many universities have a learning management system (LMS) that works as the primary content management system (CMS) for education (Popular implementations include Moodle, Blackboard and Chamilo). By nature LMS are vertically integrated and

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institutionally centralized (Mott, 2010). They are hierarchically managed, with careful access-control and has a strong structure. Web 2.0 tools (e.g. Wiki) are, on the other hand, loosely connected, highly-dynamic, decentralised systems. There are arguments that flexibility, portability, adaptability, and openness make Web 2.0 tools (sometimes known as PLE) far superior to the LMS as a teaching and learning platform. It is important to understand that the two approaches are essentially two convenient locations on the continuum from steep hierarchy to user-centeredness.

A good analogy is the difference between a corporate web site and Wikipedia. By necessity, a corporate web site makes users essentially readers. This does not mean that users are not allowed to interact at all. They may be allowed to provide feedback, participate in (often moderated) blogs and chat rooms. However, the essence of the design is a one of tight-control and hierarchy. On the other hand, on Wikipedia every single user is allowed to create and edit content and participate fully and completely in the construction of knowledge. Again, this does not mean that there are no entities who are "more equal than others". For example on Wikipedia there are (volunteer) editors who keep lookout for content vandalism and there are mechanisms (though not completely foolproof) to block blacklisted users from editing content.

There are convincing arguments for supplementing LMS with PLEs. For example:

> "Although the LMS needs to continue serving as an enterprise CMS [course/content management system], it also needs to be a student-cantered application that gives students greater control over content and learning. Hence, there is continual pressure for the LMS to utilize and integrate with many of the Web 2.0 tools that students already use freely on the Internet and that they expect to find in this kind of system. Some educators even argue that the next requirement is a PLE that interoperates with an LMS"

(Agee et al., 2009, as quoted by Mott, 2010).

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2.6 The Wiki way

One of the obvious candidates for the web-based system was a popular Web 2.0 tool – Wiki (Leuf and Cunningham, 2001; Parker and Chao, 2007; Svinicki and McKeachie, 2011, 235–266 pp.). Salient features of a Wiki are (a) invites all users to edit any page or to create new pages; (b) promotes meaningful topic associations by linking content within the system and with external resources and; (c) exist comfortably as an on-going process rather than a finished product. By the end 2006 there has been a proliferation of Wiki frameworks to choose from. We selected Mediawiki the open-source software Wikipedia runs on (Wikipedia, 2011; Barrett, 2008). We already had some experience in putting mediawiki for non-standard uses (Pathirana, 2006a,b). The major modifications have been done to prevent content from being open to public (password protection) for reading and editing. Technically this has been a simple objective to achieve (Pathirana, 2006b; Barrett, 2008). We implemented the system on a dedicated Linux Server hosted in-house.

3 A five year experiment

The Web 2.0-based system (see Fig. 1) was first introduced to the students on 22 December 2006 to a group of students from the department of urban water and sanitation. Every year in September (when the students are about to start their research) the system was opened to a new group of students as follows: first, a short (two hour) tutorial was conducted to introduce the system and guide the users through the basic use (reading, searching, editing and content uploading, internal and external (web) linking). After that each user was issued a password to access the Wiki. The users were asked to do the following throughout their thesis period:

– Every student maintains her own user page where primary information on the thesis project is kept. However, the user can create any number of other pages if needed.

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- Before a meeting with the supervisor, student should either write down or upload the material for the discussion (e.g. a computer model for review, a summary of a research article read or a description of a case-study). After meetings students were encouraged to write a summary of the meeting.
- Whenever students make presentations, they upload the slides to the Wiki.
- Access other students' pages for reference material and comment on them.
- Contribute where possible to the upkeep of resources like model configurations, computer programs, data etc. in the system.

3.1 A process more than the product

We emphasized the importance of seeing the Wiki as a process rather as an end product. Students were encouraged to create content that describes "products" that are not yet complete (e.g. ideas that needs further thinking, Models with problems running, computer programs needing more improvement, draft versions of presentations). This was a difficult habit to cultivate and needed frequent reminders. For example it had been common for students during their first few months to resist uploading a presentation because "it is yet to be shown to the supervisor".

3.2 Linking knowledge

One of the distinct advantages of using a Wiki is the ease with which related information could be linked. External links can be created to various WWW resources. Internal links can be made to other pages or specific locations of those pages. We employ internal links for three main purposes: (a) linking to "authoritative sources" (e.g. a tutorial created by a user and peer reviewed), (b) linking to past work (e.g. a related thesis project done in a previous year) and (c) organizing information in "meta-pages" (e.g. a page listing all the projects of year 2008).

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3.3 A supporting environment

A mere technical framework would not have achieved our objective-principles of creativity, healthy competition and teamwork, leading to effective learning (Smith, 2008, p. 58). The planned regular educational activities revolved around the Wiki and reinforced these principles. On an average at a biweekly frequency, group meetings were organized where all students presented their research progress and discussed the problems. Students were encouraged to think about their colleagues' problems and suggest possible solutions. In almost every meeting one or two students were invited to make longer (15–20 min) presentations on their research achievements. All these meetings were organized in a very informal setting, more like platforms for "thinking out loud" and exchanging ideas than to deliver formal presentations. More often students presented problems and issues than solutions and invited peers to suggest solutions.

Most of the students in these groups were involved in mathematical modelling of urban hydrological/hydraulic problems. Many of the highly-recurrent issues were of technical nature: issues to do with (a) computer programming and (b) advanced use of modelling software. From year 2007 an annual four-day seminar on advanced computer programming (known as "programming boot camp") was conducted. The entire learning resource (a self-study tutorial of around 90 pages and numerous case-studies) of this activity has been developed on the Wiki system with collaboration of students. Every year we solicit the contribution of the students to enlarge and improve this material.

There were many technical issues related to modelling that were common for many research projects. (One typical example being how to programmatically link a urban hydrological model to an optimization algorithm and a simple financial model.) In these situations we reaped maximum benefits of having a Wiki system. Typically a teacher helps a student to solve this problem. Then we invite her to author an article on the Wiki on how to solve the particular problem. The future students were simply guided to the article and were asked to improve it as they solve their own (related) problem.

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In many occasions a number of masters research projects are being planned in sequence: a thesis completed in a given year may feed in as the starting point of a thesis in the next year. As an example: the first thesis focuses on the development of a coupled 1-D/2-D hydraulic model suitable for modelling urban flood inundation problems. In the second year a student would use the model to couple it with an optimization algorithm to solve a risk-based urban drainage design problem. The Wiki provided a natural framework of continuity for such situations. The second student would start off by linking the resources from the predecessor to his own page, reviewing them and understanding how they work (all these steps are recorded on the Wiki).

The membership of a user is not revoked after the user leaves the institute. Many graduates continue to access the Wiki as a resource to refer to their own research work and to those of the colleagues, which may help solving some current problem.

There are no restrictions on what a user can do inside the Wiki. Everyone can edit any page, add new pages or alter any material. The system is based on trust – everyone respecting the guidelines. However, everything that is being done on the system has been recorded, so that if a mistake happens (e.g. deleting a page, uploading the wrong document) it is extremely easy for others to correct it. We follow the operating principles of Wikipedia.

3.4 The growth of the system

We have collected statistics on the use and growth of the Wiki over the five year period (2006–2011). Every year around ten to fifteen students are being added to the system (see supplement), currently we have 89 accounts, including the involved faculty. There has been almost a linear growth of content (see supplement) over the period resulting around 2500 different pages as of November 2011. As shown in Fig. 2, the user activity shows a bimodal annual pattern, which can be explained with the nature of the progress of a typical thesis project. The first peak (September–October) signifies the starting period of the thesis where students prepare proposal, do literature survey (they upload all their literature to the Wiki) and defend the proposals. The second peak

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(January–March) is the period many students obtain significant results (which they upload to and discuss in the Wiki), write the bulk of the thesis (again, they keep all the work in progress as well as the final copy on the Wiki) and prepare for the defence. Currently the system achieves around 2800 files totalling to a size of about 24 GB of data (see the supplement).

3.5 Evidence for cross referencing

One of the important goals of the Wiki system is to encourage later users to refer to already completed work. In order to demonstrate this use of the system few present the cases of two students:

Student A did research from September 2008 to April 2009, on "Optimal Planning of Water Distribution Network for developing world using criticality theory", using a case study from *Minneriya* town, Sri Lanka. Large amount of data from the study site, which included, hydraulic properties of the water distribution system and material and other asset data (including failure information) of the network assets, were collected by the student. A new calculation algorithm for improved simulation of drinking water networks under sub-optimal operating conditions, was developed. Later, a number of students based their thesis work on these two sources.

Student B developed a Multi-Objective optimization framework for her research entitled "Development and Application of Urban Flood Risk Management Decision Support Tool using Multi-Objective Optimization", by integrating 1-D dynamic flood simulation model with an efficient multi-objective optimization algorithm (October 2008 to April 2008). Several students over the later years utilized her framework as basis for their own flood related optimization work.

Figure 3 shows the number of page and file downloads from those two user's pages in the period March 2010 to January 2012. This figure shows one of the important aspects of the system, namely, how students use their predecessors findings as basis for their own construction of knowledge.

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4 Emergent uses of the Wiki

The primary and intended use of the Wiki system has been to serve as a platform of academic information construction and sharing. The system increased the efficiency of both the students and the faculty involved in the supervision. At the same time, some atypical uses of the system also emerged over the years.

4.1 A medium of backup

Keeping regular backups of work in progress has been an important task, often forgotten by computer users. From the beginning it has been observed that some students started using the Wiki system as a convenient place to keep a backup copy of their work in progress. Later this has been actively encouraged and some barriers for that use (e.g. limit of maximum upload size) being removed. One of the salient features of the practice being the fact that making backups became a part of regular work and communication with the peers (e.g. uploading a draft of the thesis serves the dual purpose of sharing it with your group for comments as well as its safe-keeping). Recognizing the importance of this role, we started making off-site automated backups of the entire Wiki, making it one of the safest places in the institute to store information.

4.2 A permanent archive

Every student has been asked to keep a digital copy of their draft-thesis and the full set of working data and techniques on the Wiki during the entire period of finalizing their work. Without any extra effort, the final snapshot of these materials is being left on the system when the student leaves the institute. Very soon the Wiki became the primary source for the involved supervisors and later students to find reports and material on past studies.

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4.3 A mobile storage

Many users started using the system as a mobile storage. When they move between computers (e.g. at the campus and at home) and visit overseas on field data collection missions, Wiki helped them to seamlessly access the latest version of their work at progress. Graduated students routinely use the Wiki to access information for later use. Past users commented that they have utilized this functionality of the system when they travel and when they are in need to access to the past work to discuss with a stakeholder or a fellow researcher.

5 Impressions of the students and educators

5.1 Students' impressions

On the fourth year since the opening the Wiki (2010) we sent a questionnaire on the process of masters degree supervision to the group of five students graduated in the year 2008–2009. This questionnaire included the following question regarding the Wiki system: "We used a Wiki system for storing information and communications within the group. Did this help you? Was it a distraction? Give your views." Overall the students comments on the Wiki were positive (see supplement). One respondent said "I believe that Wiki system made the learning and research processes very simple. It contains most important software tools, module/course work materials and reference publications and works done by the students and staff members. This allowed us to exchange thoughts and materials efficiently. It also kept us in track with what has been done by the other members. In addition it encourages the spirit of team research work. Simple ideas are sometimes the most difficult thing that hold-up the progress on the research work. However, the Wiki system gave us the opportunity to know with whom to discuss whenever we face any challenges during our work."

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While this feedback has not been a part of a scientific survey, it gave us the indication that the users were satisfied with the Wiki system and continue to recommend it after they finish their studies at UNESCO-IHE.

5.2 Educators' impressions

Feedback from graduated students indicated that they liked the employment of Wiki in the thesis research phase. However, it was very rarely the case that the students liked to use the Wiki system from the beginning. In fact, in every year most of the students appear to start using the Wiki due to persuasion (before the first peak) of the supervisors. Activities listed in Sect. 3 have been commonly employed to get the students to use the system gradually in spite of the natural resistance showed by many to try an unfamiliar approach. Almost all students have had read articles on Wikipedia – but most were just "readers" and did not comprehend how it worked as a social medium of knowledge construction. While the initial training sessions (Sect. 3) have been helpful to get the students started on usage, few were convinced about its utility until they tried it for a month or so. The second peak (February–March) occurred without encouragement from the supervisor; by this time the students have become used to the system and have realized some of its benefits by experience.

Another important aspect of the Wiki system was that it demanded negligible time-involvement from the supervisors, beyond the normal supervision activities. In fact, some features (e.g. immediate availability of latest results of a student) worked to save time and increase overall efficiency. It also encouraged peer to peer learning which enabled wider problem solving and dialogue rather than approaching the mentor immediately in case of doubts and apprehensions.

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6 Discussion and conclusions

We employed a specialized Wiki to manage the process of thesis research in hydrology over a period of five years. This is a good point in time to look back and take stock of the experiences and share the findings with the other hydrology educators.

Embarked as an open-ended experiment in 2006, we are now convinced of the possibility of employing wiki to enhance the effectiveness and efficiency of the process of thesis research in hydrology. However, we did not make the a-priori assumption that our students are from the fabled "Net-generation" and that the use of Web 2.0 tools (Wiki in the present case) is a necessary response to fill in a generational gap between educators and students. Perhaps the demography of our students (mid-career professionals from third world water organizations) prevented us from making that assumption. In this respect, one of the most important reasons why the proposed Web 2.0-based approach has been successful is that we never assumed that the students are well-versed in the art of collaborative web. Rather, we strived to create an environment where the students gradually familiarised themselves with the system and the benefits of its use. This, in our view, is a key element for success in introducing innovations in education.

We introduced an open ended and largely egalitarian system. The system has not been driven by a few to be "used" by the rest. By nature, Wikis follow a participatory approach that has been leveraged in this specific application. Every user has been allowed to express their own style for content creation; the educators rarely interfere with the way students created content.

The above experience confirms the place of PLEs could play in addition to LMS in today's higher education. While, for some applications the vertically integrated nature of LMS is very much needed, we wish to point out the fact that the flexibility that has been needed to allow the student to express themselves freely, has been often lacking in typical LMS systems, unless they are supplemented by user-centric tools like Wikis. Managing thesis research in hydrology, the current case study, is an example: we have been dealing with broad and diverse problems that need trans-disciplinary scientific

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approaches to solve; the process of education should reflect this diversity in real-world and the tools employed should being flexible to support that. Based on our experience during this study, we stress the appropriateness of Web 2.0 (user-centric) techniques in this context.

Employment of ICT in water education is important means to improve the overall educational experience. However, mere use of it does not necessarily make education a more effective and student-centred process. What matters more are the underlying principles of an educational environment. In this context technological innovation has been a mere aid that helps implementing those principles. In the present case those were: (1) collaboration, (2) healthy competition and (3) freedom of expression within a secure environment. We have deployed a specialized Wiki system as a tool to help achieve those objectives. At the same time we have organized a number of related activities (e.g. frequent, informal meetings, various tutorials for common problems, encouraging peer instruction) around the existence of the Wiki. It was this integrated environment that made the concept work, rather than the technological approach taken in isolation.

The Wiki system encouraged the collaboration among students very effectively: the group of students very soon become a community where each person knows what others do – both scientific research and set of specific skills they are developing to achieve their objectives (e.g. use of a particular hydrological model). First the group meetings introduce them to each others' worlds. But the presence of a current snapshot of everyone's work on the Wiki solidifies this understanding. Every year we observe the collaboration naturally arising within this context, with some help from the educators. For example, students had started asking help from each other and discussing their problems on their own initiative.

the differences of Web 2.0 PLEs and LMS in section "*LMS and Web 2.0*" above. There are some distinct benefits of deploying Wiki-based PLEs in terms of knowledge construction that became apparent during this study. LMS systems are generally organized in a course based structure. While an LMS like Moodle is technically capable

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of hosting Wikis these are components of specific courses. However, using both the systems during the last five years – Wiki for the purpose of thesis research, Moodle for classroom teaching – we are convinced that Wiki has several important advantages for the purpose described in this manuscript, which include,

1. Wiki promotes an egalitarian spirit – everyone is equal within the system, while by necessity LMS are vertically integrated.

2. With features like automatic-version control and logging of all activity Wikis are more robust to deploy in an unrestricted context.

3. Wiki facilities in LMS (e.g. moodle) are components of a course. They are designed to be deployed over a run of the course and to be archived upon conclusion of the course (so that the next run of the course can be started fresh).

Clearly non of these "disadvantages" of LMS are not impossible to overcome. However, this implies significant customization of the system and could lead to larger administrative burden. One the other hand Wikis are designed to provide these functionalities. We fully agree that for classroom use and for distance education LMS like Moodle are the appropriate tools. However, we argue that there are distinct advantages in using Wiki over LMS for supporting student research groups.

Our application of the Wiki system was done in a very specific context: while the research problems have been diverse, most of the students were using modelling tools in their work. There have been several modelling tools (e.g. hydrological models, network-hydraulic models) and other techniques (e.g. evolutionary algorithms for optimization) that have been commonly used by many students. This context made the system more effective – for example in terms of collaboration among students. A natural question that arises is whether this approach can be used outside this specific context.

In our opinion another area that can benefit from this work is research groups focused on laboratory experiment based research. Whether it is hydraulic/hydrological lab work or water technology experiments, there are a number of skills the students need to

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develop while engaged in lab work. While the research themes change, many of these skills change much slowly, making it quite useful to record past experiences for the benefit of the future users.

Our (limited) experience in using this system for case-study based research, where the student travels to a remote location to conduct field work did not produce encouraging results. There have been situations where slow internet connections being too slow to use the system effectively. However, even in cases where this has not been an issue, we have noticed that the students' use of the system is often not sustained throughout a period of long absence from the group. We attribute this behaviour to the importance of other ingredients total integrated environment (e.g. frequent meetings where students meet each other face to face, peer-teaching).

Can this approach be applied to a group of any size? While we do not have information to conclusively state, it is our opinion that the system works best only as long as the group is small enough for the members to know each other personally (maximum 10–15?). This is quite suitable to manage a typical "research group" in hydrology with one or two scientists and a number of graduate students. The best strategy to deploy such a system for a typical educational department is to organize a series of clustered, but completely independent set of Wikis – one for each group.

From a technical point of view, apart from Mediawiki, there are many comparable Wiki systems that can be used for this type of applications. In fact, some of them could be more suitable for "private" Wiki systems like the one presented. For example DokuWiki or PmWiki provides the access-control mechanisms (allowing only password-based access) by default.

In this paper we have presented a five-year case-study of using Web 2.0 technology (Wiki) in the context of thesis research management in hydrology. Properly supplemented with suitable supporting activities, this approach can provide a framework that fosters collaboration, healthy competition and unrestricted thinking and expression – elements that are essential work solving substantial water problems – in the students. We conclude the following:

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1. Employment of Wikis is an excellent way of building research groups in thesis research in hydrology.

2. The deployment of new technology is but one ingredient to establish an effective learning environment. An integrated environment of activities geared towards this objective, that feed and nourish each other is needed to effectively strive for this goal.

3. PLEs like Wikis have an important place in hydrology education in managing graduate research.

Supplementary material related to this article is available online at: http://www.hydrol-earth-syst-sci-discuss.net/9/2541/2012/hessd-9-2541-2012-supplement.zip.

Acknowledgements. We acknowledge the helpful contribution of Corrie de Haan who read an early version of this manuscript and provided a number of helpful suggestions to improve it. We thank all the students and staff members who contributed in this experiment.

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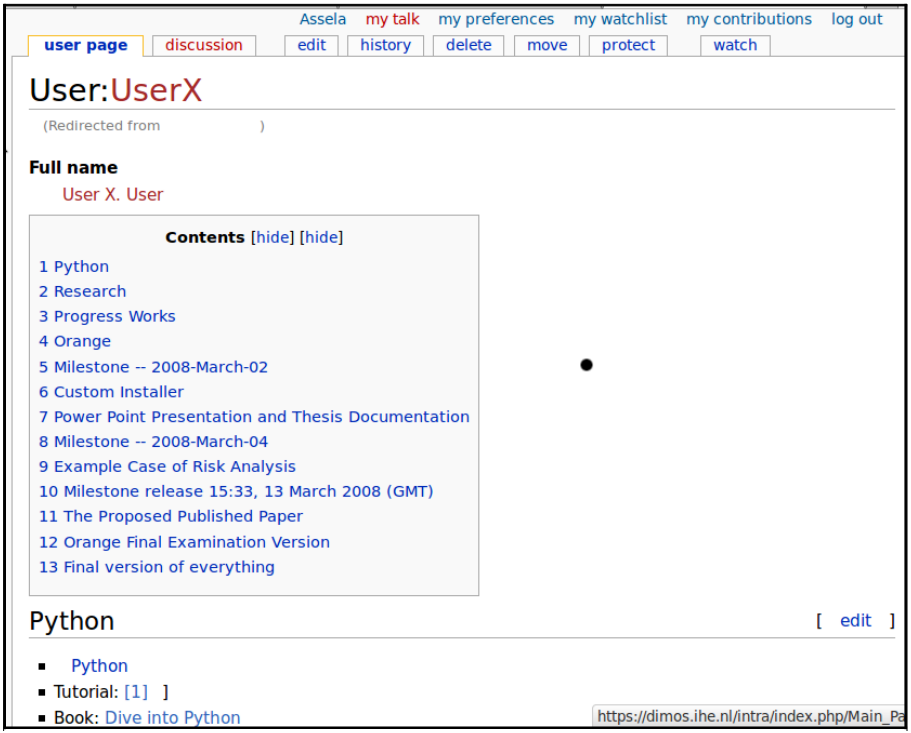

Fig. 1. The top portion of a user page (A Student from 2007–2008 group).

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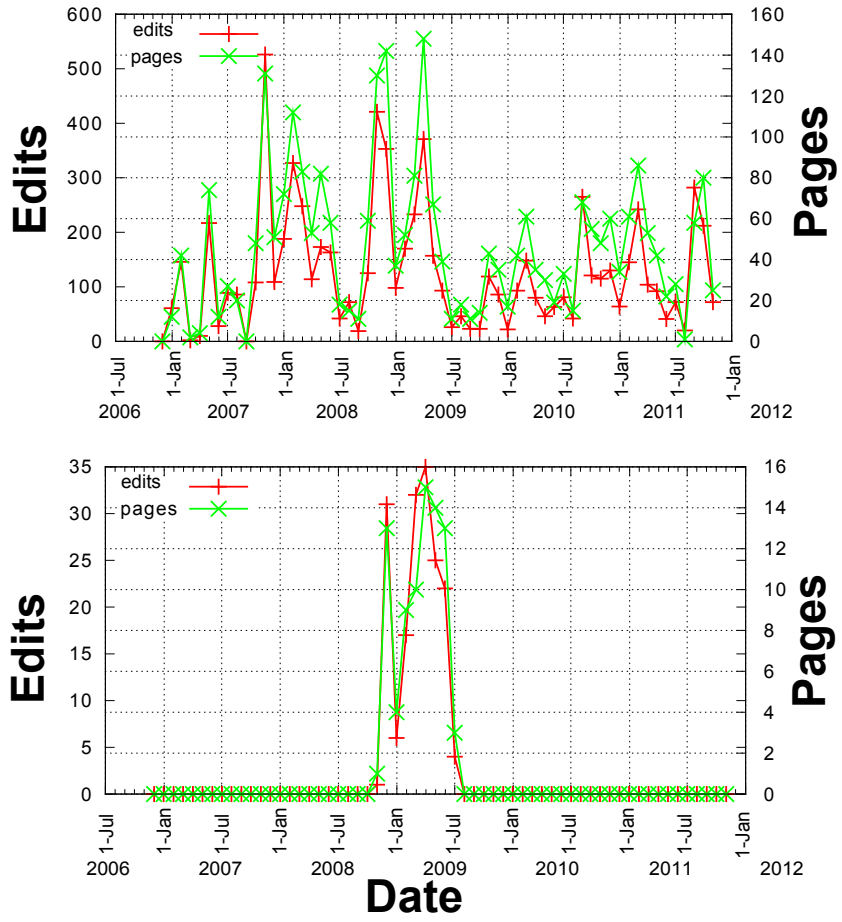

Fig. 2. Monthly breakdown of new pages and edits (top panel). Activity report for a single user (A student from the group 2008–2009) (bottom panel).

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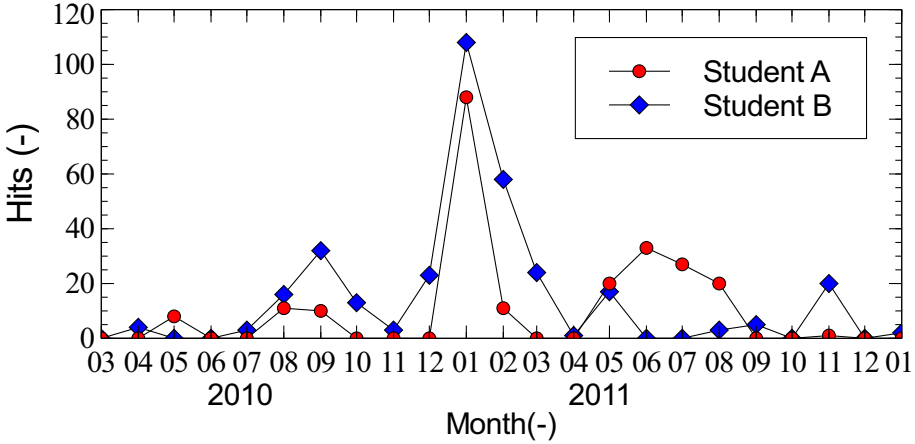

Fig. 3. Downloads of material from pages of Student A and Student B (2008–2009) the period March 2010 to December 2011, by other students.

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