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Web 2.0 Approaches for Active, Collaborative Learning in Medicine and Health

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ABSTRACT

In recent years, advances in information and communication technology and especially the Internet have acted as catalysts for significant developments in the sector of health care, having a strong impact in supporting medical diagnosis, enabling efficient and effective patient and healthcare management and reforming medical education. There is currently an international trend to involve computers and the Internet heavily in medical curricula, in continuing life-long medical learning, as well as in general health education of the public. However, effective technology-supported interventions are usually created when there is a successful alignment of the specific requirements with the potential end use of technology. And it is just such a juncture we are currently facing with the emergent paradigm of Web 2.0. This chapter elaborates on the potential of Web 2.0 for active and, potentially, effective learning in medicine and in health and reviews current practices and emerging advances in the field. Discussion focuses on current and emerging applications that fully exploit the potential of Web. 2.0. Finally, the envisaged merit of merging with Web 3.0 technologies is also discussed.

INTRODUCTION

Current innovations in information systems and communication services mark the switch from an "information society", characterized by mass information seeking and based on the distribution of pre-defined and standardized data, to a "knowledge society", that is, a society based on knowledge as a value. This emphasizes the cognitive advancement and involvement of each individual. The growing use of Internet not only modifies quickly and habitually the way people work but it also leads the race in this educational revolution.

The penetration of technology and the Internet in medical education, and in education in general, created a new situation where the teacher as mediator to knowledge can often be bypassed while the individual strives for knowledge based on their own efforts and aided by the vast amount of information and educational activities presented in the Web. When new technologies where first introduced in education

about two decades ago (although experimental attempts date back to 1970s), there was a considerable hype about the emerging electronic teacher, which fortunately soon enough subsided to reveal serious limitations of the computer-to-student education model (Dertouzos, 1997). The emerging Web 2.0 paradigm however is promising to bring about yet another new situation, where the conventional human mediator as well as the electronic mediator in the form of the Internet and the Web is replaced by virtual dynamic communities of peers that learn and advance together.

This chapter will elaborate on the potential of Web 2.0 for active and, potentially, effective learning in medicine and health and review current practices and emerging advances in the field, providing an indicative overview of various projects were Web 2.0 is used to support health and medical education. The chapter will also present some example emerging application areas where Web 2.0 is expected to find its full implementation by enabling new online educational experiences not previously possible to achieve, including full support of active learning, new ways of assessment and evaluation, content sharing educational communities and content repurposing in medical education.

BACKGROUND

Education in Medicine and Health

Medical education is drawing much attention, due to its special characteristics. Firstly, it is a field that encompasses not only the fundamental issue of education, but also the sensitive issue of health and health care services. Furthermore, education in medicine is multidisciplinary and rather long, involving a good number of academic years and extending to life-long continuing updating and learning. Additionally, medical education is traditionally based on a two-fold model: theoretical instruction based on textbooks and clinical practice with one-to-one interaction.

Finally, one should stress the current enormous expansion in medical and biomedical knowledge, which constitutes a fundamental challenge in medical education (Papaioakeim et al, 2006). As a result, two main issues arise in medical education: (a) the necessity for overspecialized learning material and educators; and (b) the trend towards a disease-based approach, rather than the more intuitive patient centered view.

In order to address these problems, medical education is embracing tools and approaches from two different fields. On one hand, alternative educational approaches have long been introduced in medicine. These include integrative curricula delivered via active, self-directed, student-centered, experiential learning. One the other hand, information technologies are also being employed to harness information explosion and support teaching in various ways. Ultimately, these two different fields could combine their contributions, with information technology effectively supporting active learning in medicine.

Traditionally, medical education requires students to sit through hours of lectures on basic sciences and discussion takes place in large groups, sometimes with the whole class present. Advances in our understanding of learning processes now suggest that such techniques may be suboptimal, and that learning should evolve from learning by acquisition to learning by participation. Thus, new educational approaches build on concepts of adult education. They rely on situational learning and are active, self-directed, student-centered, and experiential (National Research Council, 1999). Learning is perceived as a qualitative change of one's conception of phenomena and ideas (Marton et al, 1977) and, consequently, knowledge must be actively processed by the student. A fundamental idea is that learning is organized in small student groups, i.e. tutorial groups, and not around lecture meetings. In the tutorial group students actively work with reality-based situations to formulate problems and learning needs that will guide their further studies. The teacher's role is that of facilitating learning rather than transferring knowledge. In the tutorial group, the students discuss and defend their choices and standpoints. Using library resources, text books, databases, laboratory work, field studies, lectures and other forms of faculty resources, they are

urged to find answers to and perspectives on their problems and learning needs. The aim is also to develop problem-processing skills, self-directed learning skills and group competence (Ehlers, 2007; Fyrenious, 2005). In response, professional organizations worldwide have called for increased emphasis on training in life-long, self-directed learning. The emerging view is of learning as an active, constructive, social, and self-reflective process (Berliner & Calfee, 1996). These basic research findings on learning suggest the need for educational environments that are learner-centered and knowledge-rich, guided by assessment, and situated in a community of learners (Schuable & Glaser, 1996). In higher medical education, educational programs increasingly include case-based or problem-based learning and other small group instructional models, collaborative organizations to support student-faculty interactions, and technology-enhanced educational tools (Jones et al, 2001).

Here, we should also stress tacit or personal knowledge, as articulated by Polanyi (1958,1998). Tacit knowing refers to the taken-for-granted knowledge at the periphery of attention that allows people to understand the world and discern meaning in it. In this respect, knowing and doing involve practical knowledge that depends on humans' ability to learn from experience. Medical knowledge is simultaneously explicit and implicit with certain aspects already well known and easily transferable, and others that are not yet fully known and must still be learned (Sturmberg & Martin, 2008). Thus, current academics prompt for attention not to exclude tacit knowledge and the means for its attainment (e.g. observation of task performance, and recursive practice) from medical education (Henry et al, 2007; Heiberg Engel, 2008).

Information & Communication Technologies in Health and Medical Education

Like many other cognitive domains, medical education can be considered in terms of a number of levels of increasing complexity and importance (Davenport & Prusak, 2000): information (i.e. processed facts), knowledge (i.e. information with a purpose), and understanding (i.e. conscious knowledge, achievement of explanation and grasp of reasonableness). This refers and includes both explicit knowledge (those aspects of mental activities that are verbal and conscious), as well as tacit knowledge (a prerequisite to discern meaning of a situation).

Technology has been employed in diverse ways to support different levels of the educational process. Supporting the dissemination of information is the easiest and most straightforward achievement of information and communication technologies. They have extensively and successfully been used to give quick, easy and cheap access to information sources, such as books, textbooks, atlases, medical and biological databases, research journals etc. Structuring and organizing information with a particular educational purpose refers to knowledge. On the other hand, understanding implies experience as well as inquiring (Williamson et al, 2002). Managing and supporting these levels of the educational process is a rather complex issue. Technology can certainly help by providing digital teaching files for the student to practice, together with tools that support continuous self-evaluation and mediate teacher-learner exchange. Of major importance is the potential of hypertext technology to provide interconnected pieces of information, and link questions with explanations within the wider scope of a particular medical task.

However, in order to promote knowledge and understanding in medical education, information technology, and especially the Internet and the Web, should embrace and support active learning approaches. It has been argued that computer mediated communication can be used to enhance collaboration and interaction within learner's groups. Especially, asynchronous discussion boards give the opportunity to analyze interaction and learning, measuring participation levels and interaction patterns. A comprehensive review of general research and practices in the area is presented by Finegold and Cooke (2006).

In retrospect, it is possible to identify three generations of information technology supported learning, which usually come under the collective term of "e-learning". The first generation is based on multimedia

technology support, such as videos, CD-ROMs or other stand-alone educational software. The second generation employs telematic technologies and it is basically set up as teaching via the Web, where conventional educational material, as well as entire educational courses, are delivered via the network to remote students. The last, emerging generation, is about web based learning, where the Internet is used as a means to create active, context based, personalized learning experiences. This last generation of e-learning shifts the emphasis from 'teaching' to 'learning' and from the notion of technology as a didactic mediator to the notion of a sociable, peer-supported, involved learner.

Web and Web 2.0

The Internet and the Web were initially a static structure with passive viewers. Moreover, they were mainly targeted to human users, with the central role of information distribution – programs had little to do in this environment. Currently the Web is changing towards a second generation of dynamic services and communication tools that emphasize on peer-to-peer collaboration, contributing and sharing, both among humans and programs. This revolution is usually known under the collective term Web 2.0. In Web 2.0 the user is seen as a contributor, rather than a recipient. Content is created by participation and collaboration as an emergent product of human interactions. In the core of Web 2.0 lies an ensemble of standards, protocols, technologies and software development architectures and approaches that enable the seamless communication of third party programs thus creating the communities and networks of services that bring people together. One can argue that a major characteristic of Web 2.0 is the fact that it continually improves and grows in size, function, complexity and approach, thus making the term even more uncertain and difficult to define. An incomplete attempt to summarize what Web 2.0 refers to is given in

.

Initially, the term Web 2.0 was coined by O'Reilly (2005) as an attempt to emphasize the fact promising new features such as 'social software technologies' were emerging. Web 2.0 is not a program or an upgrade or a single concrete piece of technology, it is rather a more fully implemented Web. It is based on the same infrastructure and standard protocols, and on well-proven technologies and tools of the Internet and the Web. However, the term Web 2.0 encompasses a whole new meaning and a collective emergent behavior of the use of these technologies, tools and applications that create networks and communities of users (both humans and programs) that enhance and promote:

- Collaboration and Sharing: Together with collaboration comes sharing of information and personal attitudes. For example social bookmarking, where not only links and services are shared, but their collaborative tagging and rating gives a new dimension to information organization.

- Participation: People of any background, culture, age etc. can participate without the need to understand the underlying technologies. Participation is perceived equally as accepting and as providing information (including adding new information items, as well as commenting and feedback on existing information). Core examples include wikis, blogs and personal profiles.

- Reuse: Content and information is discovered, used and re-used via notions such as content syndication and supporting technologies that allow programs and humans to build their own content aggregates and distribute them.

- Openness: Information is freely shared among humans and programs, thus promoting the notion that knowledge cannot be owned. Intellectual property rights do carry over from conventional publishing to online information sharing as supported conventionally on the Web. However, the

participative character of Web 2.0, with emphasis on user generated content and on content sharing among peers, is currently leading to a paradigm shift.

- Agility: Function and content from many sources (personal and third party alike) are combined to create new added value for individuals. This can always be readily shared with others. Mashup applications are a major example.

- Personalization: Content and service openness and reuse make it easier to customize information, function and their intertwining to create personalized experiences, such as personalized curricula etc. Dynamically interlacing all this individual contribution, a 'wisdom of crowds' emerges. A striking example is the controversial new form of metadata for the organization of information, coming under the term 'folksonommies', as opposed to 'taxonomies'.

- Apomediation: A term coined by Eysenbach (2007) to characterize the third way for users to identify trustworthy and useful information. The first approach is to use some sort of mediation, e.g. a librarian or a teacher, in the case of education. The second approach is to bypass such mediation (commonly referred to as disintermediation), and this has been the basic role of conventional Web, with students seeking additional information on a variety of web-based information sources. In this third approach, enhanced and realized by Web 2.0, the user seeks information with peer guidance, as a result of networked collaborative filtering processes.

All this emergent behaviour that characterizes Web 2.0 is enabled one way or the other by a variety of applications and tools that form the core of Web 2.0, and by their turn are empowered by an ensemble of technology, embracing both familiar technology from the early days of the Web as well as innovations. Among common Web 2.0 tools that are being explored for their possible use in education are wikis, blogs, podcasts, social networking tools and virtual worlds (Alexander, 2006).

Wikis are dynamic, group-developed websites that can be edited, updated or changed by anyone who has access to them (usually any visitor). The current status for wiki technology includes pages with fruitful discussions on each entry and there is always the ability to view the evolving history of an entry and recover previous versions. The most well-known wiki is Wikipedia (www.wikipedia.org), the online editable encyclopaedia.

Blogs is a short form of the term Weblogs, because it started as online diaries (logs) written by individuals on the Web. They are basically dated entries in reverse chronological order, and this is where the similarities with a conventional diary end. Blog entries can contain a variety of multimedia material and links to other web resources; can be commented by other users, while information can be organized by user defined and generic tags. An newer form of blog, known as microblogging, restricts the size of each posting, allowing it however to be submitted by a variety of means, e.g. conventional blog entry, instant messaging, email, etc., thus allowing for easy and often updates.

Mashups are web applications that merge data from one or more sources and present it in new ways. In many cases this is made possible by data providers that develop application programming interfaces (APIs) for their data. These APIs follow standard web service protocols and/or generic internet formats to represent data (such as RSS) and can easily be implemented in different programming languages. At the same direction notification services offer continuous updates of web sites in a standardized way for use in mashups and in a variety of other applications. Usually under the term "RSS feed" borrowed from the commonly used data representation standard RSS (meaning Really Simple Syndication or, as renamed, Rich Site Summary), they include summarized text and respective metadata and they can be read either by standalone special purpose software or by software embedded in commonly used internet tools (e.g. web

browsers, mail clients, etc). RSS feeds and similar syndication technology is also used to distribute streams of audio and video data files to personal computers and portable media players – what is known under the term podcasting.

FIGURE 1
(removed due to copyright issues)

Figure 1. A pictorial summary of what Web 2.0 refers to.

Social networking websites focus on creating online communities of individuals who publish their content and activities while exploring others content and activities. Such sites cover a variety of topics and provide most of web 2.0 tools and technologies for users to interact. Therefore an astonishing number of simple or more sophisticated social networking sites are currently emerging ranging from mere casual social networking to collaborative web bookmarking and searching, school teacher rating, collaborative document and spreadsheet editing, etc.

Virtual worlds are simulated environments were individual users participate via fictional avatars. Their implementation on the Internet provides a unique way to realize fictional communities for individuals to freely meet others, communicate, participate in a variety of activities and eventually learn.

Most often web 2.0 sites combine more than one of the above applications, and have in common a variety of tools and features that enhance participation and collaboration such as search engines, links to other resources, ability for the user to add content and/or comments, tools for organizing content (e.g. tags, extensions by similarity, rating, etc), and signals for updates (McAfee, 2006). Web 2.0 tools and applications make use of a range of technologies, mainly based on common internet and web technologies, that is the HTTP protocol and the suite of web development technologies, such as all variations of HTML and XHTML and CSS, XML and XSLT, Javascript, etc. Currently the core of this basic suite of technologies comes under the collective term AJAX (Asynchronous Java Script and XML), an interrelated group of web technologies used to develop interactive web pages that process user requests immediately.
However, it can be argued that the real predecessor of web 2.0 notions and technology is the programming paradigm of web services and service oriented architectures. Web services are a middleware technology for developing service-oriented architectures (SOAs). A SOA refers to a collection of interconnected software entities (services) that provide some capability through exchange of messages, and can be described, discovered and invoked over a network. Web services are loosely defined as self-contained, self-describing, modular applications that can be located and invoked over the Internet. Web services are based on open internet standards: build on the HyperText Transfer Protocol (HTTP), they use XML for data presentation while messaging is described in an XML-based messaging protocol, SOAP (Simple Object Access Protocol). Web services describe themselves through a standardized Web Service Description Language (WSDL) document, and can be published to one or more Intranet or Internet repositories for potential users to locate through a standard Universal Description, Discovery and Integration (UDDI) registry. A whole suite of additional standards have been developed to formally address issues such as security, reliability, transactions, et cetera. REST is a technologically simpler approach to web services that bypasses the SOAP communication protocol and concentrates on getting information content of a web page from its published XML file that contains desired information via the HTTP protocol. This core technology that supports Web 2.0 is continuously evolving and growing, as new

specialized formats, standards, and protocols emerge. Examples include the RSS data/metadata XML format, the FOAF (Friend of a Friend) and XFN (XHTML Friends Network) protocols involved in social networking applications.

As a final remark, it should be noted that quality control takes up a new meaning in Web 2.0, and can mainly be ensured and applied via a model pretty much different from that in Web 1.0 and other conventional information sharing channels. As already stated, the major characteristic of Web 2.0 is open participation of everybody. Thus, here the role of the conventional moderator is usually taken up by the collective group of participants, rather than a single authority. The collective body of participants is responsible as a whole to reject or amend, alter, etc. content and behaviour that is not proper and of good quality. In the case of employing Web 2.0 in the educational setting, the group is usually limited to the identifiable participants of the specific educational experience/activity, and thus their contribution is not anonymous and certainly has the corresponding repercussions to their educational evaluation and overall outcome. However, in general such a structure of the collective, participative nature of Web 2.0 can indeed be problematic in terms of information quality. Thus, one should be aware of this and limit the use of such technology and the corresponding paradigm to certain situations where it is really suited. As with any technology or breakthrough, Web 2.0 is not a panacea, and should not (and will not) replace everything else. It is merely a different form of technology and approach, which should (and hopefully will) find its proper use and place in medical education, and in general.

WEB 2.0 IN MEDICAL EDUCATION

Initial involvement of the Web to support education was based on the metaphor of a virtual classroom, where by the web application follows the model of a real classroom conducting a conventional lecture, discussion, workshop and other educational activities (Cronje, 2006). In 2001 after a systematic and critical meta-analysis of more than 330 studies comparing technology enhanced versus conventional education, Russell concluded that there is no significant difference between various learning/teaching methods (Russell, 2001). Nowadays, it is widely accepted that this is an inappropriate comparison, as the use of technology not only changes the way education is deployed, but has a profound effect in the pedagogy itself. Therefore, it turns out that the discussion is about how technology and the Web in particular, can stimulate a new learning culture and find novel, alternative ways to advance learning (Ehlers, 2007). Thus, one should concentrate and highlight whatever unique characteristics a new technology exhibits and strive to exploit in full such characteristics, changing the conceptual paradigm along with the technological one.

As presented in the previous section, web 2.0 salient characteristics include, among others:

- effortless communication and collaboration among peers,
- ample access to alternative sources of information, usually customarily combined at a meta-level,
- reporting and rating of information within open communities of peers,
- potential for different representations of the same content (for people with special needs, with different cultural backgrounds, different ages, different background), and
- context based organization of resources and activities.

However, despite all the above unique and exciting characteristics, in its early days Web 2.0 is still used in the majority of cases to hold and provide content (albeit created dynamically and via peer participation and collaboration) and then systematically deliver it to students. The following paragraphs give an indicative overview of some such projects where Web 2.0 is used to support health and medical education, while the next section presents some example cases where this evolving web paradigm is or can be exploited for completely novel educational experiences.

Current Web 2.0 Applications in Medical Education

Nowadays, blogs are used in various educational settings and in many different ways, but mainly as a replacement of other forms of asynchronous computer mediated communication, merely because of their additional functionality, such as updates via feeds, notion of ownership, decentralization, tagging, archiving and the reverse chronological order organization of content (Kim, 2008). In educational settings, usually blogs are limited to a particular audience, e.g. participants of a course. Thus, blogs in education are mainly used to publish articles and other educational material, as well as to keep track of class activities, often spanning across semesters and years of studies. Various medical schools worldwide have incorporated blogs in their web-based learning management systems, for instructors to post their comments and get students to submit their questions and suggestions, and in general to serve as reflective diaries for various educational experiences (McGee & Begg, 2008). They have even been used to post personal assignments (e.g. Cobus, 2009). Medical blogs may also include discussions about clinical cases, images and special clinical interest topics, thus supporting continuous education amongst medical experts; such an example involves using blogs for an online version of the conventional medical journal club (Genes & Parekh, 2009). Current literature includes a number of projects where blogs have been used to recreate almost any kind of conventional educational activity, ranging from personal educational experience recording, to posting of assignments and exams, to communication amongst peers and between instructors and students, to collaboration within learners groups. It is evident that the ease, with which one can publish content on a blog, makes blogs good candidates for any kind of educational use. However, it is also evident that most of the time the only good reason for using a blog in all those cases is this very ease to publish, despite the fact that a blog may not always be the best suited technology for the particular task. Indeed, blogs are yet to find their most pertinent application in medical education.

Wikis are increasingly used in medical education, as an ideal tool for collaborative work done by both students and teachers. At first, educational wiki implementations involved the mere development of material in the form of an online encyclopaedia with free contribution from anyone. This created a number of medical Wikipedia like (www.wikipedia.org) websites, which at some point were put under scrutiny for their lack of contributors' authentication and the quality of the content while addressing the sensitive area of health and medical education (Pender et al, 2008); although there have been proposals to overcome such shortcomings, e.g. by developing technological solutions that enable authorship tracking of each bit of information (Hoffmann, 2008). Additionally, such wiki applications do not fully exploit the web 2.0 paradigm for peer collaboration, engagement and participation when the educational process is considered. Currently new applications are emerging where wikis are used as a classroom metaphor for students collaborating on a group report, compiling data or sharing the results of their research, while faculty might use the wiki to collaboratively develop the curriculum of a course. Tonkin (2005) argues that different educational uses of wikis can include single-user wiki, used more like a blog without the date format, to hold and edit over time personal thoughts and output of the educational endeavour. Collaborative wikis can also be used along the metaphor of a lab book, collaborative writing assignment, or with the aim to produce a knowledge base, and a comprehensive review of published work supporting this is given by Parker & Chao (2007). Yet, wikis can find their place in medical education when used not as a substitute for the handing in of paper reports or the in-class conventional collaboration, but rather when their potential for distributed peer educational engagement is fully exploited. An interesting example involves use wikis for initial ice-breaking collaboration among students during the initialization phase of a course (Augar et al, 2004). More fully implemented applications employ wikis to support collaborative learning, for example in the case of the social learning within communities of practice (Wenger, 2000), that is, networks of individuals and institutions that share common practices, goals and problems about a certain topic. In this case, wikis can act as an evolving knowledge platform where members can share pieces of information, discuss and collaborate (Schaffert et al, 2006). Some more examples are presented in the next chapter.

Podcasting can be used for archiving and distributing lectures in video or audio format. It can especially enhance the learning experience in demanding hands-on educational environments such as in medicine (Boulos et al, 2006). Although such podcasting uses are closer to traditional passive learning and web paradigms, they can free class time to be used for problem-solving, project sessions and other active learning activities (Kurtz et al, 2007). An example of using podcasting to support collaborative and active learning can be found in the initiative of the Duke University, where podcasts are created both by teachers and students, covering not only formal educational material, but discussions as well as feedback comments on assignments etc. (Belanger, 2005). A number of medical professional associations and other related bodies are increasingly distributing educational podcasts, while many scientific medical journals are now offering content in the form of podcasts (Agrawal, 2007; Wilson et al, 2009).

Teachers and learners are also turning to video-sharing sites (such as www.teachertube.com) to share educational videos. Social networking sites are also used in various educational settings. Collaborative writing is supporting by a number of respective websites that offer tools for collaborative text editing (such as www.thinkfree.com and docs.google.com). A striking example that fully realizes the web 2.0 paradigm is del.icio.us (http://delicious.com/), a collaborative bookmarking web site, that allow users to share their bookmarks, creating their own tags and organizing dynamically bookmarks (on any possible topic and within any context, including educational subjects and contexts), thus creating a vibrant bookmark folksonomy that evolves over time.

Finally, virtual worlds on the web are increasingly used to create fluid learning communities which can be engaged in real world didactic situations, collaborate to approach solutions to problems, seek knowledge, and communicate and interact with peers – a comprehensive review is given by De Lucia et al (2009). Although there is a large number of virtual worlds dedicated to learning, when generic virtual world web environments are used, such as Second Life (http://secondlife.com/) and There (http://www.there.com/) there is the additional advantage of the vast size of the community that participates and can potentially engage in learning activities (Kelton, 2008). A review of such application in medical education is given by Boulos et al (2007).

Nowadays most of the above applications and tools are combined and intertwined within the same web site or service to give hybrid added value applications, enhancing the web 2.0 paradigm and the corresponding emergent behaviors mentioned above. A representative example is presented by the NHS Scotland e-Library (http://www.elib.scot.nhs.uk/) where various web and web 2.0 tools and techniques are employed and combined to create Managed Knowledge Networks (Caldwell et al, 2008). In this case, web technology is used to link resources, services and people in a multitude of ways with the aim to provide a structure that supports the complete information cycle from recognizing the need for information, locating information, and then sharing knowledge to the benefit of the wider community using technology, which ensures seamless access to explicit and tacit knowledge at point of need.

As a final comment, it should be stressed that recent research shows an impressive web 2.0 awareness and penetration amongst medical students and qualified medical practitioners, when casual personal use is considered (Sandars et al, 2008). What remains to be seen in the near future is the most appropriate application of web 2.0 technologies and their true penetration in medical and health education.

Challenges and Emerging Applications

Web 2.0 tools have crossed Moore's chasm, easily reached early maturity and are currently under rapid development and evolution (Ebner et al, 2007). However, the idea of social learning software itself, especially in educational scenarios, is not as far developed as one may imagine, since too few innovators and early adopters are actually using Web 2.0 to enhance existing curricula designs and learning behaviours. What is also true is that web 2.0 technologies have led to a flood of new healthcare

applications and services, with the potential to revolutionise the entire spectrum of health and medicine. With areas such as consumer-led preventive medicine, public health, home care, telemedicine, clinical care and biomedical research strongly affected and enriched by the use of Web 2.0, it is mandatory that health and medical education should also follow and exploit this media, content and collaboration rich revolution.

All three levels of medical education are affected, namely, undergraduate, postgraduate and continuing medical education (or profession development), as well public education and awareness. In all these levels the tools to be used may be similar, but the way of using them should be different, so as to conform to the diverse skills and learning outcomes envisaged and mandated by the particular curricula or portfolio designs. For example, in undergraduate medical learning emphasis might be placed upon the skill of recognizing information taught in a traditional classroom and attempting its sideways expansion so as to ease comprehension and knowledge acquisition. For postgraduate learners the focus is shifted more towards skills related to analyzing and/or synthesizing different facets of information from contexts of existing formal and/or tacit knowledge. In continuing lifelong learning or professional development level the need is shifted towards familiarization with new technology and/or new (evidence based) knowledge in a specified area as well as the exchange of peer experiences, activity or practice based training, and point of care or pervasive learning. In public education (or else communicating science and medicine to the public) challenges are associated with the wide diversity of the public scientific background and their differences in pursuing knowledge and health welfare.

As presented in the previous section, the majority of current exploitations of web 2.0 notions and technologies in medical education involve using this new medium to deliver education in the conventional way. However, there definitely exist those niches in the medical education era where Web 2.0 is expected to make a difference, by enabling new online educational experiences not previously possible to achieve. The following paragraphs present the authors' views about some indicative examples of such application areas.

Supporting problem-based learning

In medical education, educational programs increasingly include case-based or problem-based learning and other small group instructional models, collaborative organizations to support student-faculty interactions, and technology-enhanced educational tools. The origins of active learning and problem-based learning (PBL) date way back in the 1940s (Lam, 2005), when the idea that students may learn better by doing and by thinking through problems was first introduced (Dewey, 1944). After its introduction in medicine at the McMaster University Faculty of Health Sciences in 1969 (Spaulding, 1969), PBL and active learning in general has been applied in numerous curricula in health sciences, and has been the centre of debate and comparative studies. Recent evidence from various disciplines suggests that active learning may work better than more passive approaches in health science education, e.g. (Michael, 2006; Schmidt et al, 2006). In a recent study Kaldoudi et al (2008) proposed the combined use of various web 2.0 technologies, namely wikis, blogs and forums to support deployment of PBL sessions solely on the Web. In these PBL sessions, instruction is performed by an interdisciplinary team of experts from remote institutions, while the group of learners can be students from the same or different institutions within the consortium. Instructors collaboratively develop a problem in a wiki. Discussion is initiated via a problem's blog or forum, where students and instructors collaborate to analyse the problem, identify conquered knowledge and plan actions for problem solving. Then students search (via the Web and not only there) and collaborate to solve the case via the wiki. Student activities, progress and more importantly gained experience and competences are recorded, shared and commended on via their personal blogs. The entire learning episode and all its steps (with the final problem/answer deployment) are recorded, commended on and monitored via the wiki (final and intermediate versions) and the participants' blogs.

Figure 2 shows typical screens from such an example PBL session, which in this case is presented as an individual course in a generic open source learning management system (Moodle, www.moodle.org). The didactic problem in this case is a multi-stage PBL session on "DICOM basics" offered to students in an MSc in Medical Informatics (http://iris.med.duth.gr/elearning/). The students are expected to read through the first step, and discuss it via the problem's forum. Then, they should set out to find the answers to the questions asked, as well as answer all other questions that have been raised during the forum discussion. They have to record important steps of their search in their personal blogs, as provided within the environment. Finally, they have to provide answers collaboratively in the wiki. They are also urged to discuss each wiki entry via the special entry discussion page within the wiki.

Once the session is initialized, the students are encouraged to spend some time to get accustomed with the environment and the procedure. This familiarization phase always spawns interesting side discussions on technical issues around web 2.0 technologies as well as on educational notions and approaches, which are conducted via a second forum devoted to technical and procedural issues. Then, the first step of the problem is deployed and initial discussion is conducted via the forum. The students are encouraged to list unknown words and notions in the wiki (under a "Problem Deployment" area) and perform personal or collaborative inquiries in order to resolve them. Final conclusion for each wiki entry is reached via a discussion for the specific wiki entry. Instructors participate in all discussions with comments and cues.
An important feature of this approach is that it enables various expert instructors (remotely located) to comment on and participate in the discussions providing highly specialized knowledge in their individual field of expertise. Another interesting issue is that tacit knowledge can be recorded, archived and mined, via the blog entries of the participants. Using the provided blog, instructors can record interesting and important steps in addressing questions, thus implicitly recording their expertise in scientific problem solving. On the other hand, students can record their own process of tackling the problem, searching literature, resolving ambiguities etc. These blog entries can then be viewed collectively as PBL session entries to reveal the progression of problem solving procedure or as individual participant blog entries that may help evaluate personal progress and especially reveal skills mastered by each participant and the process of evolution in skill mastering. This use of Web 2.0 has been deployed to support undergraduate and graduate medical education (Bamidis et al, 2008), as well as for dissemination of science to the public (Antoniou et al, 2008).

FIGURE 2
(removed due to copyright issues)

Figure 2. A The front page of the PBL course in DICOM Basics and a wiki page stating the first step of the didactic problem (adopted by Kaldoudi et al, 2008).

New possibilities for assessment and evaluation

All this collaborative and participative emergent behaviour in Web 2.0 brings about and enables a novel approach to assessment and evaluation. Peer participation is enhanced and the conventional hierarchical relationship between teacher and student gives way for peer networks, with the individual on the spotlight. It logically follows that conventional student assessment mainly by comparing the individual with their peers on any given educational assignment, should be amended by other more appropriate approaches.

Luckily, web 2.0 technology can fully support this turn. For example, wikis and other social software are increasingly used for development of collaborative projects. Thus, individual wiki activities and appropriate clustering of wiki pages can be analysed in order to evaluate individual contribution to group projects (Trentin, 2009). A step beyond producing descriptive statistics, such as the number of postings per learner, number of replies, etc., one should turn towards analyzing interaction patterns in wiki discussions, in forums, and in blogs (and their comments) and see how this progresses over time, and from task to task, or from one educational goal (or problem stage) to the next, while using semantics to distinguish the purpose and outcome of interaction.

Probably, the most important advancement would come by using web 2.0 technology to help the individual analyze their own achievements both in knowledge and in competencies, either medicine specific or generic. In this case, personal blogs appropriately tagged that follow the educational progression of the individual over time, can highlight and reveal progress, strengths and weaknesses, and can be used to transfer the process of attaining the skills to achieve knowledge (rather than the achievement of knowledge itself). Thus putting focus to individual assessment as opposed to one's own history of achievement, rather than as opposed to peers' achievements. Via personal blog entries tacit knowledge can be recorded, archived and mined. Thus, experts and instructors can record interesting and important steps in exploring and appraising information, acquiring knowledge and addressing educational problems, thus implicitly recording their expertise in scientific problem solving. On the other hand, learners can record their own process of tackling information, searching literature, resolving ambiguities etc. These personal or group entries may help evaluate personal progress and especially reveal skills mastered.

Content sharing in medical education

Continuous advances in medicine and biological sciences lead to an ever expanding core knowledge relevant to the medical practice (Papaioakeim et al, 2006). Thus, medical academic institutions are increasingly required to invest in order to enrich their curricula by developing overspecialized courses and corresponding educational content. It is evident that such an overspecialized expertise cannot be readily available in any medical academic institution, thus external experts have to be involved. More-over it cannot be easily available for professional medical doctors in their life-long continuous education. Although there is an abundance of up-to-date overspecialized medical educational content available in individual academic institutions, such content cannot at the moment be easily discovered, retrieved, re-used and thus shared across institutions and among medical teachers and students.

In order to support the emerging integrative curricula structures and exploit the over-specialized knowledge available by different experts, Web 2.0 technologies can be employed to develop virtual communities of educators and learners that share their pools of autonomous specialized educational modules and provide the mechanisms for searching, retrieving, evaluating and rating, adapting and revising educational content in medicine and life sciences (Kaldoudi et al, 2008b & 2009). Such educational content sharing communities may enhance the conceptual background and support the realization of the '5th freedom', that of free movement of knowledge (added to the four original principles of free movement of persons, capital, services and goods in the European Union) newly introduced by the heads of EU states and governments on Friday, 14 March 2008 in a statement following their traditional spring summit (European Council, 2008).

USA government and academia with the "Advanced Distributed Learning Initiative", a non-profit "Corporation for National Research Initiatives – CNRI", "Learning Systems Architecture Lab – LSAL" developed an open, standards-based model for designing and implementing software systems for the purposes of discovery, sharing and reuse of learning content through the establishment of interoperable federations of learning content repositories, the so called Content Object Repository Discovery Registration/Resolution Architecture (CORDRA) (Rehank et al, 2005). Although supported by prestigious

international bodies, it seems that CORDRA architecture has not yet been widely adopted. Effective technology-supported interventions are usually created when there is a successful alignment of the specific requirements with the potential and the use of technology. Therefore, requirements for flexible, adaptive and ubiquitous online content sharing should evoke notions, practices and technologies from respective state-of-the-art evolutions in the Web.

Alternative content sharing solutions can be developed based on web 2.0 technologies (Kaldoudi et al, 2009). One such approach can be based on traditional isolated learning content management systems (LCMS), loosely associated via commonplace web 2.0 technologies. Each academic institution participating in such a virtual educational community publishes their content in their own LCMS. Notification and updates of newly published content in other affiliated LCMSs are performed by RSS feed mechanisms. Subscription to the RSS feeds can be open to institutions, educators and students alike. Independent mashup platform/repositories can store educational content, both as assets and as aggregation objects. All community participants can upload and download educational content to use on their isolated LCMS. Another alternative approach draws from the semantic web paradigm and is based on a federated architecture of LCMSs which is founded on a reference semantic web services for search, interchange and delivery of learning objects.

Content repurposing via collaborative, social networks

Considering the state-of-the-art nature of medical educational content, it is imperative that such content can be repurposed, enriched, and embedded effectively into respective medical and other related scientific curricula, clinical practice and continuing education, as well as public dissemination and awareness.

Although many higher medical education institutions often use educational resources written in non-native languages (mainly English), while some courses (especially at the postgraduate level) may also be taught in English, the rule is that higher education is and should be delivered mostly in the native language. This is especially a mandate in healthcare, as acquired knowledge should be finally communicated to the patient. Additionally, common experience shows that there is also a demand for content localization. In the case of medical, and scientific content in general, this mainly refers to different legislation and local medical regulations, different lab tests norms, reference values and units as well as different medical requirements of various ethnic groups. Moreover, we should also consider the cultural differences among different user groups within the same national healthcare system. Healthcare education addresses a multitude of professions, ranging from medical doctors to nurses and lab technicians, to basic life scientists and even healthcare administrators. Thus, the same educational content often needs to be adapted in order to be delivered to an audience of a different background. Finally, we should also note the different pedagogical cultures present in healthcare education, which range from the conventional lecturing to clinical practice and a variety of active learning methodologies. All of these educational approaches would require the same content to be presented in a different way, e.g. a lecture presentation and notes for the conventional teaching approach should be restructured to be presented as, for example, a list of questions and answers or as a series of real world problems, or a collection of interactive teaching files in the case of a more active learning episode.

Therefore, when educational content sharing is considered, the notion of re-purposing becomes a central requirement. The term re-purposing is used here to collectively refer to all instances that require any change and re-making of a particular educational content item to account for reasons such as those discussed in the previous paragraph. Content enrichment should also be considered as a requirement to all kinds of repurposing and involves adding new content and media in the form of other learning objects in order to add educational value. Standards based metadata is customarily used to describe learning objectives, learning outcomes, delivery methods, etc. Re-purposing of educational content can thus be described using such metadata which can be edited collaboratively in a social network, either by the instructor, or the student or even software itself.

The structure of an educational object that is repurposed may not necessarily change, but the key differences should be emphasized, described and organized in terms of a variety of tags, including time evolution, and other attributes. This brings in web 2.0 technologies. For example, consider a wiki used to create and hold the metadata that describes the repurposing history of a learning object and the various versions of the repurposed object itself (Figure 3) as they evolve through different uses within a community of medical educational content sharing.

FIGURE 3
(removed due to copyright issues)

Figure 3. Using wikis for metadata creation simultaneous with educational content repurposing.

FUTURE RESEARCH DIRECTIONS

Effective online learning experiences require a successful alignment of the learning approach with the technology used. Such an inherent alignment exists between the notion of active, collaborative learning and the paradigm of Web 2.0, as they both rely on and emphasize social skills (such as collaboration, interaction and peer activity) as opposed to mere content. Within this framework, it is expected that future work will put emphasis to individual's competences for knowledge management, rather than knowledge itself. Work in progress elaborates on mechanisms to process and analyze the learning process as recorded in personal blogs, wikis and social networks so as to extract meaningful information about capturing expert's practical skills competences and share this with the novice (Kaldoudi et al, 2008).

Additionally, the current enormous expansion in knowledge (including expert competences as well) constitutes a fundamental educational challenge. Higher academic institutions are increasingly required to invest in order to enrich their curricula with courses given by external experts, while experts working within an academic institution often restrict their state-of-the-art knowledge to a very limited audience (Papaioakeim et al, 2006). In order to support the emerging integrative curricula structures and accommodate the over-specialized knowledge available by different experts, web 2.0 applications can be employed to develop virtual distributed pools of autonomous specialized educational modules and provide the mechanisms for searching, retrieving, evaluating and rating, adapting and revising educational content in medicine and life sciences (Kaldoudi et al, 2009). This is the scope of the European mEducator Best Practice Network (currently being initiated under the EU eContePlus2008 funding program), which aims to enable seamless content sharing in medical formal education. Specifically, mEducator addresses a comprehensive collection of different types of health educational material. These include conventional educational content types also used in other areas (e.g. lecture notes, books, exam questions, practicals, graphs, images/videos, algorithms and simulators, etc), educational content types unique in medical education (e.g. teaching files, virtual patients, evidence based medicine forms, clinical guidelines, anatomical atlases, etc,) and alternative educational content types, either reflecting active learning techniques (extensively used in health education) and/or stemming from newly introduced web 2.0 technologies (e.g. problem/case based learning sessions, serious games, web traces, wikis, blogs/discussion forums, etc). Additionally, mEducator focuses on implementing and comparing two alternative solutions for educational content discovery and retrieval on the web. The first solution is based on traditional isolated learning content management systems (LCMS), loosely associated via

commonplace web 2.0 technologies, using RSS feeds for notification and updates of newly published content. The second solution is based on a federated architecture which is founded on a reference Semantic Web Service (SWS) architecture for search, interchange and delivery of learning objects.

Such current research focusing on data semantics, ultimately leads to a further interesting advancement that is currently emerging and shows potential to grow into a next generation of Web, what is commonly referred to as Web 3.0. The notion and the prediction of this evolution are attributed to the founders of Web, Berners-Lee and colleagues (2001), almost a decade ago. However, the explosion of Web 2.0 has really prepared both technology and users to emerge in the paradigm of semantic networking of information and services, thus the Web 3.0 is currently arising with a promising potential for educational applications (Bratsas et al, 2008).

While Web 2.0 is seen as the evolution of the web of information dissemination towards the web of human participation and information sharing, Web 3.0 emphasizes on machine-facilitated understanding of information so as to provide a context based, intuitive user experience. Although commonly referred to as a third generation of web technology (thus the 'version' number 3.0) we would argue that it should be more appropriate to use the descriptive term "semantic Web", to address the enabling of contextual and semantic information (mainly based on appropriate metadata) to both conventional web and web 2.0 applications. Moreover, the semantic web should not be seen as opposed to Web 2.0 nor as its mere evolution, but as complimentary. A fuller implemented Web is expected to arise by the appropriate merging of notions, technologies and approaches in all 'versions' of the Web. Recently Precia & Motta (2007) showed an interesting approach of merging notions of web 2.0 collective behavior with semantics. In their work, they use collaboratively created tags used in social networking sites to automatically create groups of concepts and partial ontologies, thus merging folksonomies with the semantic Web.

In 2008 the World Wide Web Consortium (W3C) (http://www.w3.org/) has established the Semantic Web for Health Care and Life Sciences Interest Group (HCLS IG) (http://www.w3.org/2001/sw/hcls/) to develop and support the use of semantic web technologies to improve collaboration, research and development, innovation, and adoption in the domains of Health Care and Life Sciences. During the last five years, there is a considerable increase of adoption of semantic web technologies in health sciences, especially for discovering and managing the vast amount of scientific information available on the Web, e.g. (Vandervalk et al, 2009; Dumontier& Villanueva-Rosales, 2009; Manning et al, 2009).

A foreseen application and impact in the case of education is to enable more efficient information search and retrieval using conventional web content, as well as the ability to construct personalized information searches tailored to a specific educational objective; further administration and semantic linking of educational content amongst institutions and degrees is also to be expected (Ohler, 2008).

Among other things, the semantic Web is about making information and services more meaningful to individuals as well as programs. Such an environment is expected to shift focus from 'finding information' to constructing 'meaningful and relevant information maps', leading to personal learning agents that will eventually support individuals in maintaining and administering their personal education and personal learning network. Thus, collaborative, participative learning within Web 2.0 will be transformed to a context based personalized learning shared within a network society. Web 2.0 applications such as wikis, blogs, mashups and RSS feeds will contain context related 'intelligence' and the problem will not be to find relevant information, but to identify information of quality and to learn how to use it best. Last but not least, for the aforementioned developments to be well accommodated within educational systems and curricula, the pivoting importance of standardising content sharing should be understood and exploited. In other words, much work will need to be carried along the paths of describing in standard ways the content to be shared and the various learning attributes associated with it (i.e. the context).

CONCLUSION

The last few years showed an increasing adoption of Web 2.0 for active and, potentially, effective learning in medicine. As with any new technology and technology paradigm shift, first applications of Web 2.0 were mostly mere use of new technology in its most profound manner to support conventional practices, i.e. the metaphor of a virtual classroom, mainly supporting information dissemination. However, most interesting is to see how Web 2.0 can stimulate a new learning culture and find novel, alternative ways to advance medical education, by highlighting whatever unique characteristics this new technology exhibits and striving to exploit in full such characteristics, changing the conceptual paradigm along with the technological one. The real value of Web 2.0 in medical education will be revealed by those emerging application areas that enable new online educational experiences not previously possible to achieve, including full support of active learning, new ways of assessment and evaluation, content sharing educational communities and content repurposing in medical education. Emphasis with Web 2.0 should be geared along collaboration and participation and not the mere provision of content if it is to play a key role in education. The slow but sure emergence of semantic Web in combination with Web 2.0 creates even greater hopes and anticipations.

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