Title	The use of Web 2.0 technologies in school science
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Source	*School Science Review, 90*(330), 113-117
Published by	The Association for Science Education

The use of Web 2.0 technologies in school science

Kim Chwee Daniel Tan and Thiam Seng Koh

ABSTRACT Web 2.0 technologies can be defined as Web-based services or products that allow individuals to share digital resources with one another, to engage each other in conversation and to collaborate with one another so that they can collectively construct knowledge. This article discusses the potential uses of Web 2.0 technologies, for example RSS feeds, social bookmarking applications, blogs, podcasts, wikis and immersive virtual environments, to facilitate students' learning of science, especially in the 'long tail' region of science education outside the standard science curriculum.

Information and communication technology (ICT) has the potential to enhance enquiry-based science education, for example by helping students to experience scientific phenomena through the use of multimedia simulations (Hennessy, Deaney and Ruthven, 2006), to collect, process and display real-time data through data logging (Linn, Davis and Bell, 2004; Tan *et al.*, 2006), and to visualise abstract scientific phenomena through animations (Osborne and Hennessy, 2003). In addition, the World Wide Web provides a convenient platform for students to gain access to recent developments in science, connect with scientific communities, and facilitate collaboration among themselves and with members of scientific communities (O'Neill and Polman, 2004).

More recently, the increasing convergence of ICT and mass-media technologies has led to the evolution of the World Wide Web from Web 1.0, a read-only Web, to Web 2.0 (see *Websites*), a read–write Web. In the past, only people and companies with the relevant technical expertise could easily create and provide content on the Web, while the rest could only view what was presented. Now, with the availability of user-friendly Web 2.0 technologies for content creation and communication, people are producing content without needing much technical expertise and also have easy, fast and convenient means of communicating and collaborating with one another across the world. Similarly, today, students are no longer mere consumers of content on the Web; they are now able to produce their own content on the Web easily, as well as evaluate and comment on the content created by others. This ability of students to be 'prosumers' allows them to have access to a wide range of scientific information and also to learn science through a mass participatory learning process. This participatory learning process potentially allows students to tap into the collective intelligence of like-minded peers, teachers and members of scientific communities, and in some cases, the primary experts themselves, to evaluate the soundness of the scientific information that they produce, for example through enquiry-based projects.

Uses of Web 2.0 technologies in secondary science

Web 2.0 technologies have important uses in secondary science as information, productivity, assessment, visualisation and simulation tools. These uses are summarised in Table 1.

Information tool

Science teachers and students can obtain science-related information, such as biographical information on famous scientists or the development of particular concepts or theories, easily on the Internet, as they can tap into collective intelligence to gain quick access to interesting nuggets of information, often current, from Web 2.0 technologies such as blogs, podcasts, wikis and social bookmarking

Table 1 Framework for uses of Web 2.0 technologies

Uses	Examples of Web 2.0 technologies
Information	● Wikis such as *Wikipedia* (http://www.wikipedia.org/), *PBwiki.com* (http://pbwikicom/) and *Curriki* (http://www.curriki.org/) for creating and revising content on science collaboratively. ● Blogs, videocasting or podcasting for posting content and for others to respond to the content posted, for example, *Science Blog* (http://www.scienceblogcom/), *ScienceBlogs* (http://scienceblogs.com/), *Science News Blog* (http://www.sciencenewsblog.com/) and the collection of University of California at Berkeley at *YouTube* videocast (http://www.youtube.com/ucberkeley). ● Websites such as *StudyCurve.com* (http://studycurve.com/) that links US middle school students to experts for finding answers to their questions. ● Social bookmarking websites such as *Del.icio.us* (http://del.icio.us/), *StumbleUpon* (http://www.stumbleupon.com/) and *Connotea* (http://www.connotea.org) rely on collective intelligence on the Web to find desired content.
Productivity	● RSS feeds such as *Bloglines* (http://www.bloglines.com/), *Google Reader* (http://reader.google.com), *NewzCrawler* (http://www.newzcrawler.com/) and *FeedDemon* (http://www.newsgator.com/Individuals/FeedDemon/) for staying informed of the latest content on websites such as those on science news or science-based blogs. ● Instant messaging such as *MSN Messenger* (http://www.msn.com/), *Yahoo Messenger* (http://messenger.yahoo.com/), *Chatzy* (http://www.chatzy.com/) and *Skype* (http://www.skype.com/) for staying in communication through chat, audio and video conferencing. ● Remote instrumentation to allow students access to sophisticated equipment such as *Bugscope* (http://bugscope.beckman.uiuc.edu).
Assessment	● E-portfolios for tracking learning such as *Edu-portfolio.org* (http://www.eduportfolio.org/en/index.php), *Open Source Portfolio Initiative* (http://www.osportfolio.org/), and *KEEP Toolkit* (http://www.cfkeep.org/static/index.html). ● Concept maps collaboratively created by students using Web-based concept-mapping tools such as *C-TOOLS* (http://ctools.msu.edu/) to demonstrate their understanding of scientific concepts. ● Multimedia websites such as *WebQuest* (http://www.webquest.org/index.php), *InstantWebQuest* (http://www.zunal.com) and *PHP Webquest* (http://eduforge.org/projects/phpwebquest/) collaboratively created by students to display their science project work which others could critique.
Visualisation/ Simulation	● Photo websites such as *Flickr* (http://www.flickr.com/) and *Zoto* (http://www.zoto.com/) allow individuals to interact with one another over the photos shared. ● Video websites such as *YouTube* (http://www.youtube.com/) and *Teacher Tube* (http://www.teachertube.com/) allow individuals to upload videos for sharing and to post comments. ● Immersive virtual environments such as *Second Life* (http://www.secondlife.com/), *River City* (http://muve.gse.harvard.edu/rivercityproject/) and *Active Worlds* (http://www.activeworlds.com/) potentially allow the design of simulations and virtual learning spaces that are collaborative and experiential.

applications. Blogs and podcasting make it easy for individuals to post content on the Internet and for others to respond to the postings with their comments. A *Google* search on the terms 'blogs' and 'science' will result in numerous blogging sites that are science-related, such as *Science Blog*, *ScienceBlogs* and *Science News Blog*. The major popular science publications such as *Nature*, *Science* and *Scientific American*, major news channels such as ABC and BBC, print newspapers such as the *New York Times* and the *Guardian*, and organisations such as NASA and the Boston Museum of Science, offer podcasts and/or videocasts on science topics to reach their target audience. Tertiary institutions are also producing podcasts and videocasts of lessons for teaching as well as marketing purposes. For example, the University of California at Berkeley has a collection of videocasts of lessons and events that are made available to the general public on *YouTube*. This can lead to interaction between the university's faculty members and viewers (Locke, 2007). Teachers and students can download videocasts of interest using an application such as *Fast Video Download 1.5* and view the videocasts later with a media player such as *VLC media player* (see *Websites*).

Wikis allow individuals to upload multi-media content easily on to websites and, similarly to other Web 2.0 technologies, also allow other individuals visiting these wikis to update and edit the entries. The first wiki is probably *Wikipedia*, an online user-created encyclopaedia which started in 2001 and tapped into '*the collective wisdom of millions of amateur experts, semi-experts, and just regular folks who thought they knew something*' (Anderson, 2006: 65). Anderson also argues that *Wikipedia* is the best encyclopaedia in the world because it is bigger and more up to date, and the entries can be even more in-depth than *Encyclopaedia Britannica*. It was reported in *Nature* that the accuracy of the entries in *Wikipedia* was close to that of *Encyclopaedia Britannica*, though this has been contested by *Encyclopaedia Britannica* (see Giles, 2005; *Encyclopaedia Britannica*, 2006; *Nature*, 2006). This is another indication that the Internet is closing the gap between the collective work of 'amateurs' and the work of 'professionals', such that it is becoming more difficult to distinguish between the two groups (Anderson, 2006). However, not every individual entry in *Wikipedia* is up to the mark, so the entries should be read with caution; *Wikipedia* is best used as a convenient source of preliminary information.

The collective intelligence of Internet users also gives rise to 'folksonomies', where thousands of links on various topics, including science, are now categorised by Internet users themselves (Bohannon, 2007) and can be shared with any other user. For example, a general-purpose site, *Del.icio.us*, and *Connotea*, a science-specific site, offer thousands of links on science topics that are bookmarked by individuals and generally offer better indications of the relevance and usefulness of such links for scientific information than the results obtained through search engines such as *Google* and *Yahoo*. Thus, blogs, podcasts, wikis and social bookmarking applications not only provide useful and convenient access to information on science, they also provide platforms for people to share, as well as collectively build, science-related knowledge. They provide a wealth of information, collected from a very large pool of people, beyond any normal encyclopaedia, so teachers and students have a higher probability of finding any information they want from these sources, even for the more esoteric enquiries.

Productivity tool

RSS feeds provide teachers and students with a mechanism for dealing with a huge amount of information on the Internet by filtering and organising the information, and keeping them informed of any changes of content in their preferred sources of information on the Internet. The term, RSS, can refer to the following format specifications: 'Really Simple Syndication', 'RDF Site Summary' or 'Rich Site Summary' (see *Websites*). RSS feeds can be obtained through a software application called an RSS reader or an 'aggregator', which can either be loaded on an individual personal computer (PC) or be Web-based. Examples of PC-based RSS readers include *FeedDemon* and *NewzCrawler*, while examples of Web-based readers include *Bloglines* and *Google Reader*. Once teachers and students subscribe to the RSS feeds of websites that they are interested in, using either Web-based or PC-based RSS readers, these readers will automatically check and download any new content from the tracked websites at regular intervals. For example, *Google*

Reader has RSS feeds from six sources, *Cognitive Daily*, *Cosmic Variance*, *National Geographic News*, *News at Nature*, *RealClimate* and *Scientific American*, in a science-related feed bundle which students can access to get up-to-date science-related information, views and exchanges, and they can add subscriptions from other science-related feeds that interest them.

Internet messaging services such as *MSN Messenger*, *Yahoo Messenger*, *Chatzy* and *Skype* provide convenient means for teachers and students to communicate with one another through chat, audio and video conferencing. Internet messaging facilitates collaboration between teachers and students beyond their classrooms and with anybody, anywhere, at any time. Existing Web technologies also make possible the use of remote instrumentation, allowing primary and secondary students to access sophisticated research instruments housed in scientific establishments such as universities or corporate laboratories (Brown and Adler, 2008; Kubasko *et al.*, 2008). In the *Bugscope* project, students can control a scanning electron microscope from the computers in their own classrooms to study insects at high magnification (Potter *et al.*, 2001). Potter and colleagues suggested that the remote use of scientific instrumentation could become an integral part of the science curriculum if more research groups would donate time for students to use their instruments. Use of remote instrumentation allows students to pursue their interest and participate in projects using sophisticated scientific instruments and methodologies, which would otherwise not be possible in the normal school situation.

Assessment tool

There is a trend towards the use of alternative forms of assessment, such as portfolios, concept mapping and project work, as students' performances in standardised tests do not necessarily indicate deep understanding of scientific concepts and theories (Klassen, 2006). Web 2.0 technologies can be used to facilitate and simplify the implementation of these alternative forms of assessment of science learning by helping teachers and students to record, monitor and assess learning. For example, a number of free Web-based e-portfolio applications are available for use in primary and secondary education; these include *Edu-portfolio*, *KEEP Toolkit* and *Open Source Portfolio Initiative*. *C-TOOLS* from the University of Michigan (Luckie *et al.*, 2003) is an Internet-based concept-mapping tool that students can use to create concept maps collaboratively to document their understanding of scientific concepts. There is even an automatic grading utility, *Robograder*, available in *C-TOOLS* to mark concept maps. Students' project work can be uploaded on to a website using simple-to-use Web interfaces offered by wiki sites, such as *PBwiki.com*, or *WebQuests* sites (March, 2004), such as *WebQuest*, *InstantWebQuest* and *PHP Webquest*, for collaboration purposes, as well as for viewing and evaluation by teachers, peers and members of interested communities.

Visualisation/simulation tool

Photo websites such as *Flickr* and *Zoto*, and video websites such as *YouTube* or *Teacher Tube*, are convenient sources of photographs and videos for science lessons. Teachers and students can also upload their own photographs or videos of science projects or field trips on to these websites for sharing with others and for others to post comments.

Immersive virtual environments, such as *Second Life*, can provide opportunities for the creation of scientific simulations and learning environments for students to interact with the simulations and environments as well as interact and collaborate with fellow participants. For example, in *River City* (Galas and Ketelhut, 2006) students work in small research teams to determine why the residents of River City keep falling ill, making and testing hypotheses, conducting experiments and making inferences; they learn about disease transmission and scientific methods of enquiry in a more authentic situation. As immersive virtual environments become more popular (and populated) with people, educational and research institutions, and high-technology companies, it is likely that these virtual environments will play an increasingly important part in the learning of science.

Conclusion

Web 2.0 technologies can potentially support an enquiry-based science education by providing informational, productivity, assessment, visualisation and simulation tools for the learning of science. These technologies make available a wealth of information to students, connect them to like-minded peers and members of scientific communities, and provide access to expertise and equipment not found in schools (Brown and Adler, 2008). They allow students to learn science in the 'long tail' (Anderson, 2006) portion of science education, where students have opportunities to pursue interests outside the standard curriculum which would otherwise not be possible because of the lack of expertise, common interest, equipment and funding in the normal school situation.

References

Anderson, C. (2006) *The long tail: why the future of business is selling less of more*. New York: Hyperion.

Bohannon, J. (2007) Folk wisdom for web sites. *ScienceNOW*, **123**, 5.

Brown, J. S. and Adler, R. P. (2008) Minds on fire: open education, the long tail, and learning 2.0. *Educause Review*, **43**(1), 17–32. http://www.educause.edu/ir/library/pdf/ERM0811.pdf (accessed April 2008).

Encyclopaedia Britannica (2006) *Fatally flawed: refuting the recent study on encyclopedic accuracy by the journal Nature*. http://corporate.britannica.com/britannica_nature_response.pdf (accessed September 2007).

Galas, C. and Ketelhut, D. J. (2006) *River City*, the MUVE. *Learning and Leading with Technology*, **33**(7), 31–32.

Giles, J. (2005) Internet encyclopaedias go head to head. *Nature*, **438**(7070), 900–901.

Hennessy, S., Deaney, R. and Ruthven, K. (2006) Situated expertise in integrating use of multimedia simulation into secondary science teaching. *International Journal of Science Education*, **28**(7), 701–732.

Klassen, S. (2006) Contextual assessment in science education: background, issues, and policy. *Science Education*, **90**(5), 820–851.

Kubasko, D., Jones, M. G., Tretter, T. and Andre, T. (2008) Is it live or is it Memorex? Students' synchronous and asynchronous communication with scientists. *International Journal of Science Education*, **30**(4), 495–514.

Linn, M. C., Davis, E. A. and Bell, P. (2004) Inquiry and technology. In *Internet environments for science education*, ed. Linn, M. C., Davis, E. A. and Bell, P. pp. 3–27. Mahwah, NJ: Lawrence Erlbaum Associates.

Locke, M. (2007) *UC Berkeley expands online content*. http://abcnews.go.com/Technology/wireStory?id=3686285 (accessed Nov 2007).

Luckie, D. B., McCray-Batzli, J., Harrison, S. and Ebert-May, D. (2003) *C-TOOLS:* Concept-connector tools for online learning in science. *International Journal of Learning*, **10**, 332–338.

March, T. (2004) The learning power of *WebQuests*. *Educational Leadership*, **61**(4), 42–47.

Nature (2006) http://www.nature.com/nature/britannica/eb_advert_response_final.pdf (accessed September 2007).

O'Neill, D. K. and Polman, J. L. (2004) Why educate 'little scientists?' Examining the potential of practice-based scientific literacy. *Journal of Research in Science Teaching*, **41**(3), 234–266.

Osborne, J. and Hennessy, S. (2003) Literature review in science education and the role of ICT: promise, problems and future directions. *NESTA Futurelab series* (Report 6). http://www.futurelab.org.uk/download/pdfs/research/lit_reviews/Secondary_School_Review.pdf (accessed May 2007).

Potter, C. S., Carragher, B., Carroll, L., Conway, C., Grosser, B., Hanlon, J., Kisseberth, N., Robinson, S., Thakkar, U. and Weber, D. (2001) *Bugscope*: a practical approach to providing remote microscopy for science education outreach. *Microscopy and Microanalysis*, **7**(3), 249–252.

Tan, K. C. D., Hedberg, J. G., Koh, T. S. and Seah, W. C. (2006) Datalogging in Singapore schools: supporting effective implementations. *Research in Science & Technological Education*, **24**(1), 111–127.

Websites

Web 2.0: see http://en.wikipedia.org/wiki/Web_2.0

Fast Video Download 1.5: available at https://addons.mozilla.org/en-US/firefox/addon/3590

VLC media player: available at http://www.videolan.org/vlc/

RSS: see http://en.wikipedia.org/wiki/RSS_(file_format)

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