McNaught, C. (2007). E-learning. In D. Kember *Reconsidering open and distance learning for developing societies: meeting students' learning needs* (pp. 157–166). London: Routledge. (Invited chapter)

E-learning

Focus of the chapter

In some ways it is problematic to have a chapter with a strong focus on technology in a book which emphasizes the primacy of teaching and learning. However, while early uses of computer technology in the 1970s and 80s had a very modest impact on university education, the advent of the internet in the 1990s and the growing and more robust web-based educational systems on offer in the 2000s have seen a significantly greater impact on the design, development and delivery of university programmes, both on- and off-campus. It is thus useful to consider how technology has impacted on the possibilities for distance education in less developed regions of the world.

In order to have synergy with the other chapters in the book, it is important to portray technology as a set of tools and systems that may offer more options in terms of learning design. The focus of the chapter will not be to explore in great depth the explosion of technological options that are now available but will rather be to examine evidence about whether the rapidly changing offerings of technology have improved the learning environments of students in less developed regions to date, or have the likelihood to do so in the foreseeable future.

The first section of the chapter will examine a number of models used by distance education programmes and providers to give a sense of the growing range of options for higher education in all regions of the world. Several of these models are transnational and are increasingly reliant on technology. This 'macro' consideration of models will be followed by an examination at a 'micro' level of the effectiveness of several examples the use of technology in learning designs suitable for distance education in less developed regions. The chapter ends with some observations about the potential for technology to contribute to education on a global scale.

Models for distance education programmes and providers

A plethora of models for online programmes

Very few universities are totally online. For example, in 2002, 54% of universities courses in Australia used the web in some way or another for teaching and learning, though only 1.4 % of courses were fully online (Bell, Bush, Nicholson, O'Brien & Tran, 2002).
Perhaps surprisingly, distance education universities have been quite slow to adopt web-based technology into their core delivery operations, though the use of stand-alone digital materials such as CD-Roms and now DVDs is common.

There are an overlapping and complex set of factors behind the relatively sluggish uptake of technology by universities. In 1999 a large study of e-learning in Australian universities was conducted, employing online surveys of institutional practice (28 of the 38 Australian universities responded); a literature survey; and a case study of five universities at project, faculty and institutional levels (McNaught, Phillips, Rossiter & Winn, 2000). Overall, there were 14 key factors grouped into the three main areas of culture, policy and support.

Effective adoption of e-learning requires alignment of all these factors. This is true for campus-based and distance universities.

Furthermore, there are now new competitors in the higher education market. The three reports (Cunningham et al. 1998, 2000; Ryan & Stedman, 2002) explored the nature and potential impact of a plethora of new models for higher education provision. The models they identified are: 1) for-profit universities (of which the University of Phoenix is a well known example); 2) corporate universities (McDonalds is an often cited one here); 3) virtual universities (discussed in more detail below); 4) public corporate universities (the US department of Defence is an active example); and 5) service companies (a range of companies selling technical platforms, consultancy services and courseware; an interesting example is Thompson Learning which is now linked to a consortium of traditional universities through the Universitas21 global partnership).

Of these alternatives, virtual universities deserve some scrutiny. Virtual universities are distance education universities where the majority of the learning resources are accessed online and interactions are carried out online. Advocates for this mode of university appeared in the late 1980s (e.g. Harasim, 1989). However, the promise of rapid profitability from online universities has not been realized. The most striking example of failure is that of the UK eUniversity (UKeU). The UKeU started in 2000 with the UK government putting up 100 million euros to kick start this initiative, aimed at gaining a considerable share of the market for e-learning for English-speaking students at university level. However, just four years later, the UKeU was closed down and its small number of students accommodated elsewhere (Garrett, 2004).

Another oft-cited disaster used to highlight the fragility of the business models in this area is that of the Western Governors University (WGU). Founded by the governors of 19 western states in the US in 1996 with $US 2.2 million in seed money, WGU had just 750 students enrolled in nine different degree programs in 2002. However, current indications are that it may have recovered from this shaky beginning as enrollments doubled in the year 2004–2005, reaching 3,000 enrolled students (Kelderman, 2005).

It is clearly too soon to tell if virtual universities will become a key player in higher education in the developed world. However, if they are fragile in areas where the technical infrastructure is sound, they are certainly not a viable alternative at this stage in less developed regions of the world. It is more constructive to examine how distance education universities might leverage the potential of educational technology in the design and development of their programmes in ways that are financially sustainable and educationally beneficial.

The use of technology at the UK Open University

The UK Open University (OU) was the world's first successful distance education university. It began in the 1960s with a "belief that communications technology could bring high quality degree-level learning to people who had not had the opportunity to attend campus universities" (Open University, http://www.open.ac.uk/about/ou/p3.shtml). Its success appears to be due to several factors about its use of technology for teaching and learning, four of which are briefly described below:

The design of programmes is led by teachers in the discipline. The OU has a normal faculty structure with the design of academic programmes being under the auspices of the faculty. The members of a course team are normally: the Course Chair, appointed by the faculty; a Course Manager; academics who are authors, readers or editors; a number of multimedia support staff; regional staff who contribute to the design of the support network; a member of the Institute of Educational Technology advising on teaching strategy, media and evaluation; and occasionally Heads of Departments, Sub-Deans and Deans as full or ex-officio members (English, 1999). This course team structure ensures that educational considerations drive the use of technology.

Theoretical frameworks drive the use of technology at the OU. The seminal work of Diana Laurillard (1993, 2002), former Pro-Vice-Chancellor (Educational Technology) at the OU, has impacted world-wide. As illustration, a Google Scholar search on the book 'Rethinking university teaching: a framework for the effective use of educational technology' yields 18,900 responses. Central to the book is the principle that conversation and interaction are essential to the learning process, and thus appropriate uses of technology need to support conversation and interaction. These principles have driven much of the e-learning research and development at the OU.

There is quite careful research into the effectiveness of any use of technology during its adoption. One clear example is the work done by Price, Richardson and Jelfs (in press). They conducted three studies comparing the experience of OU students when tutorial support was provided conventionally (using limited face-to-face sessions with some contact by telephone and email) with their experience in the same course with online tutorial support (using a combination of computer-mediated conferencing and email). In all three studies the students reported poorer experiences with online tuition than with face-to-face tuition. This research clearly shows the needs for training for both tutors and students in the nuances of communication and how these subtleties might be conveyed in an online environment.

A broader consideration of how communication technologies might build communities for learning is taken by Weller (in press). He argued that three core principles of openness, robustness and decentralization exist with some forms of internet-based technologies (he cites Napster, blogging and open source software), and that these same three core principles underlie genuine communities for learning. So, if such communities are to be built with widely distributed students in a distance education course, then the opportunities afforded by some technologies cannot be ignored. Further, as students are increasing using these technologies for a variety of life-style purposes, the synergy becomes greater. Weller's work is a bridge between current learning technologies used at the OU (e.g. blogging) and possible future scenarios.

In tune with this focus on evaluative research, focused research occurs into innovative technologies. At the OU there is a clear separation between what might be considered 'tried and tested' technology and research into potential 'cutting edge' technologies that might be adopted at some future time. As noted above, the Institute of Educational Technology (IET) serves the needs of course teams. Their focus is on how to support effective learning in the existing OU programmes. In addition to the IET, the OU established the Knowledge Media Institute (KMI) in 1995 with a brief to focus on research and development into future technologies. Their focus is on the convergence of cognitive and learning sciences, artificial intelligence and semantic technologies, and multimedia. The term 'knowledge media' has been chosen to explain this focus. This distinction between operational support for existing

technologies and careful research into future technologies serves the OU well as technology is allowed to mature before it is implemented on a broad scale.

Adoption of technology at the University of South Africa

Let us now turn to examine how technology is used for e-learning at an open university in a less developed region. The University of South Africa (UNISA) will be used as an example. UNISA's foundations go back to 1873 as the University of the Cape of Good Hope which was essentially an examining agency for Oxford and Cambridge universities. Its current form as a distance university began in 1946. Today, across its vocational and higher education sectors, it has a total student enrolment in the region of 250,000, approximately 70,000 more than the OU in the UK. It has one main campus and nine regional campuses throughout South Africa.

The model of the UK OU has been closely studied by all open and distance universities in less developed regions, and there is no doubt that there have been wasted resources on inappropriate technologies in the last few decades. I worked in South Africa in the 1980s and was a designer of early CD-Rom multimedia materials for science. I know that many of my endeavours did not reach learners in the field. The plan was to set up computer rooms in schools which would also become study centres for adult distance learners, many of whom were teachers in schools. After initial enthusiasm, the problems of ongoing technical advice and maintenance were often too challenging and the result was that limited use was made of these resources. In addition, in the 1980s, South Africa was a country at war and other matters dominated. Indeed, computer technology often had negative connotations and associations with repressive monitoring; for example, the South African government absorbed 41% of all South African computer sales in 1986 (Leonard, 1989). After independence in the early 1990s, the availability of funding from a variety of international non-government sources decreased because, on a global scale, aid funding moved to countries further north in Africa, and also to Eastern Europe and former Soviet Bloc countries. The result was that rather wasteful utopian ideas were no longer possible and faded. So, by the time the internet arrived in South Africa, the funding available for widespread cabling and IT infrastructure was quite limited. Ubiquitous access to web-based technology is far off in South Africa and indeed all countries in sub-Saharan Africa (Ifinedo, 2005),

Similar stories of complex relationships between social, political and economic factors exist in many less developed countries and it is a reasonable generalization to say that internet-based e-learning is largely restricted to university centres in urban areas. Ojo's (2005) account of the challenges facing a telecentre in rural Uganda which "legitimatiz[ed] the inequalities in the status quo in terms of age, gender, educational qualification and socio-economic status" echoed much of my own experiences 20 years earlier in South Africa, even though the technology itself is now more sophisticated.

As a result, there is relatively little use of the internet and conventional web-based computer technology by UNISA. Quan-Baffour and Vambe (in press) described how a diverse range of 'low tech' approaches are used quite effectively with the increasingly diverse UNISA student population. These include CD-Roms, audio- and video-cassettes, radio, telephone and, of course, print-based materials. These technologies are combined with the support of local tutors – what Quan-Baffour and Vambe (in press) described as "the oral technology of the tutor's voice". One interesting new development is the increasing use of being made of text-

based short message systems (SMS) over mobile phones. I will come back to this aspect towards the end of the chapter.

Before looking at future opportunities and scenarios, a quick examination of the ways in which existing technologies are used to support student learning might be useful.

A focus on technology and learning designs

Promises and problems of course management systems

There is a bewildering plethora of course management systems (CMSs) available. These are often called virtual learning environments (VLEs) or learning management systems (LMSs), though those of us who believe that learning is not likely to be efficiently managed by computers tend to use the CMS to foreground the organizational aspects of these systems. The definition given by Wikipedia for a CMS is succinct:

> a software system designed to facilitate teachers in the management of educational courses for their students, especially by helping teachers and learners with course administration. The system can often track the learners' progress, which can be monitored by both teachers and learners. While often thought of as primarily tools for distance education, they are most often used to supplement the face-to-face classroom. These systems usually run on servers, to serve the course to students as internet pages. Components of these systems usually include templates for content pages, discussion forums, chat, quizzes and exercises …"
>
> http://en.wikipedia.org/wiki/Managed_learning_environment

Thankfully, a US-based professional organization, the Western Cooperative for Educational Telecommunications (WCET, http://www.wcet.info/) maintains an excellent online comparison tool (EduTools, http://edutools.info/) that allows the user to compare up to ten different systems on over 40 different characteristics. At the time of writing there were 61 systems available for comparison.

From the perspective of less developed countries, the cost of these systems has been a major drawback but with the advent of freely available open source software, this has now changed. One example of an open source system that is being adopted in many countries, albeit in restricted internet-serviced areas, is Moodle (http://moodle.org/). Moodle is currently used in over 160 countries, and has a large and diverse user community who speak over 75 languages. For a product where version 1.0 was released only in August 2002 this is an astounding adoption rate. One of the reasons for the success of Moodle is that it is based on clearly articulated educational principles, which are broadly constructivist (Dougiamas & Taylor, 2002). There is no doubt that where internet access exists, it is now possible for educators to use some form of course management system to provide learning resources and activities for students.

Content: The potential and pitfalls of learning objects

For the last decade a great deal of effort and resources have been expended on the development and 'stocking' of learning object repositories. One of the hopes was that this investment would provide content materials which teachers across the world could use, reuse and adapt in their own courses. This might ensure that the high costs of producing multimedia materials might be offset by widespread use. Of course, this is a somewhat simplistic

statement of the situation. The packaged modular approach to the provision of learning resources is not plain sailing. The crux of the matter is the tension between producing something which is generic enough to fit many educational contexts (including subject matter, and teacher and student preferences), and yet adaptable/ customizable to fit each context in an educationally satisfying way. Parrish (2004) is a recent authoritative review of this tension. Also, as Boyle (2003) pointed out, e-learning does not have a good track record in designing learning materials; why should the somewhat more complex job of designing reusable learning objects be carried out in a better fashion?

While there are many accounts of small-scale successes (e.g. Weller, 2004), most of the existing repositories are not used widely (McNaught, in press). The culture of reuse is not yet embedded into higher education. Community-based digital libraries have been much more successful. Wright, Marlino and Sumner (2002) commented, "a community digital library is distinct through having a community of potential users define and guide the development of the library". They were writing about a community digital library dealing with the broad subject domain of earth system education, the Digital Library for Earth System Education (DLESE, http://www.dlese.org/). My own assessment is that the potential for learning object repositories to actually assist with provision of low-cost courseware for the less developed regions will not be realized for some years. However, small-scale initiatives may grow and the concept is certainly not one that should be dismissed.

So, we now have affordable course management systems which are undoubtedly supporting distance education in internet-enabled areas. There is a fragmented, embryonic (?) learning object movement that has the potential to provide cost-effective courseware in the future. However, the main stumbling block to e-learning is still the attainment of ubiquitous access to the internet and it is my contention that the most dramatic change to e-learning across the world will come from wireless technology.

The future: Bridging the bandwidth divide with wireless systems

Again using Africa as an example, there have been expensive attempts to cable Africa in the hope that connectivity costs would be lowered enough to make web-based activity affordable for most people. There is an existing cable system, called SAT3, which goes from Portugal to South Africa and out across the Indian Ocean to Asia. The combined length of all the system segments is 28,800 km. It has 36 members who put up US$600 million to build and operate it for the life of the cable over the next 25 years. However, while connectivity is possible, costs have not been reduced, presumably because the system is operated by a series of monopoly state-owned telecommunication providers (Jensen, 2006).Work is underway for a new submarine cable to connect eight coastal countries in Eastern & Southern Africa with other global submarine cable systems, This 9,900 km system is estimated to cost US$200 million and is expected to be operational by the end of 2007. However, as a similar management model is being used, the likelihood that consumer costs will fall is not high.

Wireless technology may offer some hope for more affordable connectivity. Wireless has two major benefits in getting less developed countries connected to the internet – ease and cost (Feldman & Hawkins, 2005). Wireless systems can be locally installed or have more global coverage. Interconnected mobile phone systems now offer a clear example of how versatile and relatively low-cost wireless technology can be. Currently, there are approximately two billion mobile phone users worldwide, and many of these devices have the potential to access to the internet. Using Southern African countries as

an example, Table 1 shows that mobile phone ownership is much more common than conventional computer ownership. Tafazolli (2006) reported on the work of the Wireless World Research Forum (WWRF, http://www.wireless-world-research.org/). The WWRF identify the need to consider not only technological access but also to understand user's perspectives. In addition, new business models are needed to give affordable access to wireless technology.

Table 1: Communication infrastructure in four Southern African countries, US and UK (Czerniewicz & Carr, 2005)

	Botswana	Mozambique	South Africa	Zimbabwe	US	UK
Population (millions)	1.7	18.4	43.6	13	291	59
Literacy rate	78.9	46.5	86	90	-	-
Landlines per 1,000 people	87	5	107	25	646	591
Cell phones per 1,000	241	14	304	30	488	841
Computers per 1,000	38.7	3.5	68.5	12.1	574	460
Internet users per 1,000	29	2.7	68	43	551	423

These sentiments are echoed in the UN-sponsored World Summit on the Information Society (WSIS, http://www.itu.int/wsis/). This has been a two-phase summit Geneva in December 2003 and Tunisia in November 2005 aimed at identifying strategies to ensure "an information society for all". While the detailed declarations and reports emanating from the summit are full of lofty ideals, there is a reassuring pragmatism in several of the statements (McNaught, 2005) and a healthy evaluation of the gains made in the two years between the two phases. While WSIS encompasses much more than wireless access, this technology is seen as central to its recommendations:

> Encourage the use of unused wireless capacity, including satellite, in developed countries and in particular in developing countries, to provide access in remote areas, especially in developing countries and countries with economies in transition, and to improve low-cost connectivity in developing countries. Special concern should be given to the Least Developed Countries in their efforts in establishing telecommunication infrastructure.
>
> World Summit on the Information Society, 2005, p. 33

These indications are positive for the future of e-learning in less developed regions. The actual way in which the combination of mobile devices, open source systems and sharable learning materials might be accessed and used in a connected world is not at all clear. Harry and Perraton (1999) spoke about the 'new society' and described the newness of our society in not only technological terms but also emphasized political and economic dimensions. This was true in my work in Africa 20 years ago and it is still true now. Change is occurring on many fronts at the same time and planning must be broadly based and interdisciplinary.

Summary

In this chapter I have outlined the diversity in the models used for distance education in general and noted the centrality of computer technology to all of them. Despite this, the uptake of appropriate technology has been patchy and, in particular, totally virtual

universities are not significant players. The balanced approach taken by the UK Open University has been described and it remains as an important model for e-learning in open and distance education.

The challenges of connectivity in less developed countries have been explored, with wireless technology offering some hope for realistically priced internet access in the future. In the present 'low tech' solutions are more robust and realistic. Once (if we take a positive stance) more widespread internet access occurs, learners may be able to use mobile devices (such as phones) to connect to learning materials and have communications with their teachers and other students. Universities may be able to use freely available open source course management systems in conjunction with community-based learning repositories to have e-learning as a significant part of their endeavours. That time is still many years off but perhaps is on the horizon.

References

All in-text URLs accessed on 9 September 2006.

Bell, M., Bush, D., Nicholson, P., O'Brien, D., & Tran, T. (2002). *Universities online: A survey of online education and services in Australia*. Department of Education, Science and Training, Occasional Paper Series 02-A, Commonwealth of Australia. Retrieved September 9, 2006, from http://www.dest.gov.au/highered/occpaper/02a/02_a.pdf

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. *Australian Journal of Educational Technology, 19*(1), 46–58.

Cunningham, S., Ryan, Y., Stedman, L., Tapsall, S., Bagdon, K., Flew, T., & Coaldrake, P. (2000). *The business of borderless education*. Evaluations and Investigations Programme report 00/3, Canberra: department of Education, Training and Youth Affairs. Retrieved September 9, 2006, from http://www.dest.gov.au/archive/highered/eippubs/eip00_3/bbe.pdf

Cunningham, S., Tapsall, S., Ryan, Y., Stedman, L., Flew, T., & Bagdon, K. (1998). *New media and borderless education*. Evaluations and Investigations Programme report 97/22, Canberra: department of Education, Training and Youth Affairs. Retrieved September 9, 2006, from http://www.dest.gov.au/archive/highered/eippubs/eip97-22/eip9722.pdf

Czerniewicz, L., & Carr, T. (2005). Growing communities of practice among educational technology researchers and practitioners in development-oriented contexts: linking local and global debates, *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 1*(2). Retrieved September 9, 2006, from http://ijedict.dec.uwi.edu/viewarticle.php?id=72&layout=html

Dougiamas, M., & Taylor, P.C. (2002). Interpretive analysis of an internet-based course constructed using a new courseware tool called Moodle. In A. Goody, .J. Herrington. & M. Northcote (Eds.), *Quality conversations*. Proceedings of the 2002 Annual International Conference of the Higher Education Research and Development Society of Australasia (HERDSA). Retrieved September 9, 2006, from http://www.ecu.edu.au/conferences/herdsa/main/papers/nonref/pdf/MartinDougiamas.pdf

English, S. (1999). Change in teaching and learning at the UK Open University: An exploration of the role of the 'Course Team'. In Proceedings of the Romanian internet learning workshop 1999, *Internet as a vehicle for teaching*, Cluj, Romania, 15-28 August. Retrieved September 9, 2006, from http://rilw.itim-cj.ro/99/papers/SueEnglish.html

Garett, R. (2004). The real story behind the failure of UK eUniversity. *Educause Quarterly, 4*, 4–6.

Harasim, L. (1989). On-line education: a new domain. In R. Mason & A. Kaye (Eds). *Mindweave. Communication, computers and distance education* (pp. 50–57). Oxford: Pergamon Press.

Harry, K., & Perraton, H. (1999) Open and distance learning for the new society, in K. Harry (Ed.) *Higher education through open and distance learning* (London, Routledge & The Commonwealth of Learning), 1–12.

Ifinedo, P. (2005). Measuring Africa's e-readiness in the global networked economy: A nine-country data analysis. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 1(1). Retrieved September 9, 2006, from http://ijedict.dec.uwi.edu/viewarticle.php?id=12&layout=html

Jensen, M. (2006). Lowering the costs of international bandwidth in Africa. Retrieved September 9, 2006, from http://fibreforafrica.net/main.shtml?x=5039689&als[MYALIAS6]=Lowering%20connectivity%20costs%20in%20Africa&als[select]= No%20item%20found

Kelderman, E. (2005). Western Governors University improves its grade. *Government Technology*, January 3. Retrieved September 9, 2006, from http://www.govtech.net/news/news.php?id=92613

Laurillard, D. (1993). *Rethinking university teaching: a framework for the effective use of educational technology*. London: Routledge.

Laurillard, D. (2002). *Rethinking university teaching: a framework for the effective use of educational technology* (2nd ed.). London: Routledge Falmer.

Leonard, R. (1989). *Apartheid whitewash: South Africa Propaganda in the United States*. New York: The Africa Fund

McNaught, C, Phillips, P, Rossiter, D & Winn, J 2000, *Developing a framework for a usable and useful inventory of computer-facilitated learning and support materials in Australian universities*, Evaluations and Investigations Program report 99/11, Higher Education Division Department of Employment, Education, Training and Youth Affairs, Canberra. Retrieved September 9, 2006, from http://www.dest.gov.au/highered/eippubs1999.htm

McNaught, C. (2005). Understanding the contexts in which we work. Editorial for Special Issue on 'Open learning for development'. *Open Learning: The Journal of Open and Distance Learning, 20*(3), 205–209.]

McNaught, C. (in press). Developing criteria for successful learning repositories. In J. Filipe, J. Cordeiro & V. Pedrosa (Eds.), *Web Information Systems and Technologies I*. Dordrecht: Springer.

Feldman, A., & Hawkins, S. (2005). Creating community wireless in Africa. Retrieved September 9, 2006, from http://www.apc.org/english/about/history/english.shtml?cmd[384]=x-575-34181

Ojo, T. (2005). Wiring sub-Saharan Africa for development. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 1*(3). Retrieved September 9, 2006, from http://ijedict.dec.uwi.edu/viewarticle.php?id=51&layout=html

Parrish, P. E. (2004). The trouble with learning objects. *Educational Technology, Research and Development, 52*(1), 49–67.

Price, L., Richardson, J. T. E., Jelfs, A. (in press). Face-to-face versus online tutoring support in distance education. *Studies in Higher Education*. [expected February 2007, 32(1)]

Quan-Baffour, K. P., & Vambe, M. T. (in press). Multiculturalism and learning technologies in adult basic education and training (ABET) programmes at The University of South Africa. *Research and Practice in Technology Enhanced Learning.*

Ryan, Y., & Stedman, L. (2002). *The business of borderless education 2001 update.* Evaluations and Investigations Programme report 02/1. Canberra: Higher Education Group. Retrieved September 9, 2006, from http://www.dest.gov.au/highered/eippubs/eip02_1/eip02_1.pdf

Tafazolli, R. (Ed.) (2006). *Technologies for the wireless future: Wireless World Research Forum (WWRF)*, Vol. 2. New York: Wiley.

Weller, M. (2004). Learning objects and the e-learning cost dilemma. *Open Learning, 19*(3), 293–302.

World Summit on the Information Society. (2005). WSIS outcomes documents. December 2005. Retrieved September 9, 2006, from http://www.itu.int/wsis/promotional/outcome.pdf

Wright, M., Marlino, M., & Sumner, T. (2002). Meta-design of a community digital library. *D-Lib Magazine, 8*(5). Retrieved September 9, 2006, from http://www.dlib.org/dlib/may02/wright/05wright.html