

# Connexions: An Alternative Approach to Publishing

Geneva Henry

Rice University, P.O. Box 1892, Houston, Texas 77251-1892  
ghenry@rice.edu

**Abstract.** Web technologies offer new methods for quickly sharing and disseminating knowledge. Digital libraries of scholarly assets are proliferating online, with materials being openly licensed and shared. Sharing knowledge provides learners, instructors and researchers with access to the most recent findings, encouraging more rapid breakthroughs that lead to positive impacts to society. These new publication processes pose challenges to traditional publishers by redefining methods for providing quality information in a timely manner. The Connexions project at Rice University is a collaborative, community-driven approach to authoring, teaching, and learning. By collaborating both within and across disciplines, communities of authors work together to pool their expertise in the form of knowledge modules. These modules form the basis for building courses that are authored by many, with each author receiving attribution for his or her contributions. Information can be modified under an open license to tailor the material for the audiences of learners.

## 1 Introduction

Scientists and engineers working in disciplines where new discoveries impact the well-being of society and result in transformational products increasingly demand fast paced communications that will accommodate their rapid knowledge discovery needs. Traditional peer reviewed publications are bottlenecks for researchers seeking to understand the latest discoveries that will aid them in identify the most fertile areas for new breakthroughs in their respective fields. To close this gap in timely communications, researchers increasingly rely on informal exchanges of knowledge with their colleagues around the globe using Internet technologies. This exchange of information electronically is leading to new cultural norms. Communications are becoming less formal since they can occur much more frequently with e-mail. Written electronic communications are beginning to approximate dialog. Jointly authored papers can quickly evolve as authors pass “the token” to each other during revision cycles. Geographic location is no longer a barrier to participating in research and publishing the results. Sharing knowledge is valued rather than keeping it hidden until research results are published in peer-reviewed journals. The result is increased collaboration, more rapid dissemination of research results, and breakthroughs occurring more rapidly [1].

In addition to facilitating more rapid advances in research, electronically available information can benefit educational institutions by enabling the inclusion of new knowledge in the curriculum to ensure that students graduate with the most current

knowledge available in their field of study. A greater challenge, however, lies in providing an infrastructure that researchers, authors, instructors and students need to easily facilitate shared communications. Traditionally published textbooks, whether in print or electronic format, have generally continued to be the means adopted for teaching and learning, even as collaboration has increased with the availability of the Internet. This paper describes an alternative framework to enable rapid knowledge exchanges and collaboration without relying on traditional peer reviewed publications to mediate between members of these knowledge communities.

### **1.1 Quality Control and Easy Sharing of Knowledge**

Quality control of information has relied on the peer review process to ensure that published works are verified as legitimate by the most knowledgeable professionals in a given field. Publishers have been the honest brokers of knowledge, arranging for articles and books to be peer reviewed by an author's disciplinary colleagues prior to publication. While the peer review process helps to ensure high quality and integrity, the process is long, resulting in delayed publication of new findings. Thus, the rapid sharing of knowledge is compromised. With the Web, however, authors can publish their findings immediately, with their peers weighing in just as immediately on the legitimacy of the new knowledge. The widespread dissemination afforded by the Internet subjects this knowledge to the scrutiny of many more experts who can confirm or deny the claims of the author. Web publications, however, are perceived as lacking the quality assurances that non-experts and third party institutions need in order to recognize the work as legitimate [6,7].

Despite the rapid information updates enabled by the Web, traditional publishers have maintained all the aspects of traditional print publications in their e-publications. Articles and books are peer reviewed before they are published on the Web with the publisher's stamp of approval. Just as with the print publications, sharing of knowledge continues to be delayed. Textbooks, the mainstay of teaching for many science and engineering disciplines, discourage collaborative authoring due to the detailed interactions required between the author and publisher. This causes authors to write about specialties in which they are not experts so that the textbook is comprehensive. Once published, the works cannot be quickly updated because changes would compromise the "approved" text that has been through the peer review process. Thus, electronic publications become frozen, just like their paper counterparts. Students cannot realize the benefits of electronic publications such as a decrease in the costs of textbooks and a genuinely current understanding of their field.

Online counterparts to print publications are beginning to receive new challenges from new models of publication. Consumers and authors alike have much to gain from the free exchange of knowledge, especially with regard to rapidly impacting both intellectual and technological growth. [5,6,8,9] Higher education institutions will, in time, find the legitimacy they require for published works through other means, such as increased use and citation of online books and articles; in time, this will likely factor more meaningfully into the measure by which the faculty and researchers are judged.

## 1.2 Motivation for Collaboration and Sharing Knowledge

The traditional publication process, with its revision cycles, copyright assignments and delayed publication due to pre-publication peer review all present barriers to co-authoring books and articles as a community. Today it is common for researchers to work with each other across institutions and geographic boundaries. In online environments, colleagues can share knowledge freely, allowing works to be annotated, discussed, reworked and rapidly republished. [19] Shared knowledge results in new ideas, hypotheses, discoveries: the advancement of knowledge.[1,15]

As authors take advantage of the way they can communicate online, they are finding it is possible to communicate much more effectively by incorporating simulations, images, audio and video in their works. This promotes further collaboration as knowledge creation becomes a team effort, with programmers, artists, and multimedia specialists working with the author, who is trying to find the best way of delivering his or her message to interested parties.

Interactive content not only conveys knowledge in new and exciting ways, it *requires* electronic publication rather than static presentation. Traditional publications are limited in how they can accommodate these new expressions of knowledge. To address the interactive nature of an online publication, some publishers issue CDs with their print publications, enabling interactive elements to be captured for the consumer. Self contained multimedia objects are limited in their ability to deliver the desired information as authors work more and more in the “web” of collaboration, linking to other resources that help to better illustrate their communications. New forms of dynamic publication come much closer to approximating a dialog, engaging colleagues and students in the work by inviting feedback and allowing them to derive new works from ideas expressed online.[7]

The spectrum of shared online content traverses the publishing continuum, with some projects simply collecting existing Web resources and providing services to help users explore relevant sites for their use in education (e.g., the National Science Digital Library (NSDL) [13]), while others provide free access to full courses an institution has developed (e.g., Open CourseWare (OCW) [12]). [18] Sharing knowledge, however, requires an environment that invites participation by the community rather than the *push* models these dissemination sites currently provide. The Connexions project at Rice University [4] seeks to fill this need by providing a repository and environment to facilitate shared authoring and publication, course composition, knowledge exploration and personal customization of knowledge resources to meet the needs of students, instructors, authors and researchers.

## 2 Connexions: a New Model for Freely Sharing Knowledge

The Connexions project began in the fall of 1999 as an idea, building into a vision, for moving teaching and learning from a static, linear progression through a set of topics to a dynamic “ecosystem” of shared knowledge. Figure 1, below, shows the process of creating and using knowledge with Connexions. In Connexions, communities of instructors, authors and learners share knowledge, continually

updating it and weaving together a variety of concepts to provide a more comprehensive perspective on how topics across disciplines interrelate. Today, Connexions hosts a repository of openly licensed knowledge modules, with over 2,000 unique modules available at no charge. The goal of Connexions is to provide and maintain a commons where individuals and communities worldwide can create and freely share knowledge. This is accomplished through the following 5 objectives that guide the projects activities: 1) Provide a *content commons* of free, interconnected educational materials; 2) Facilitate *access* to the commons and foster its *growth*; 3)

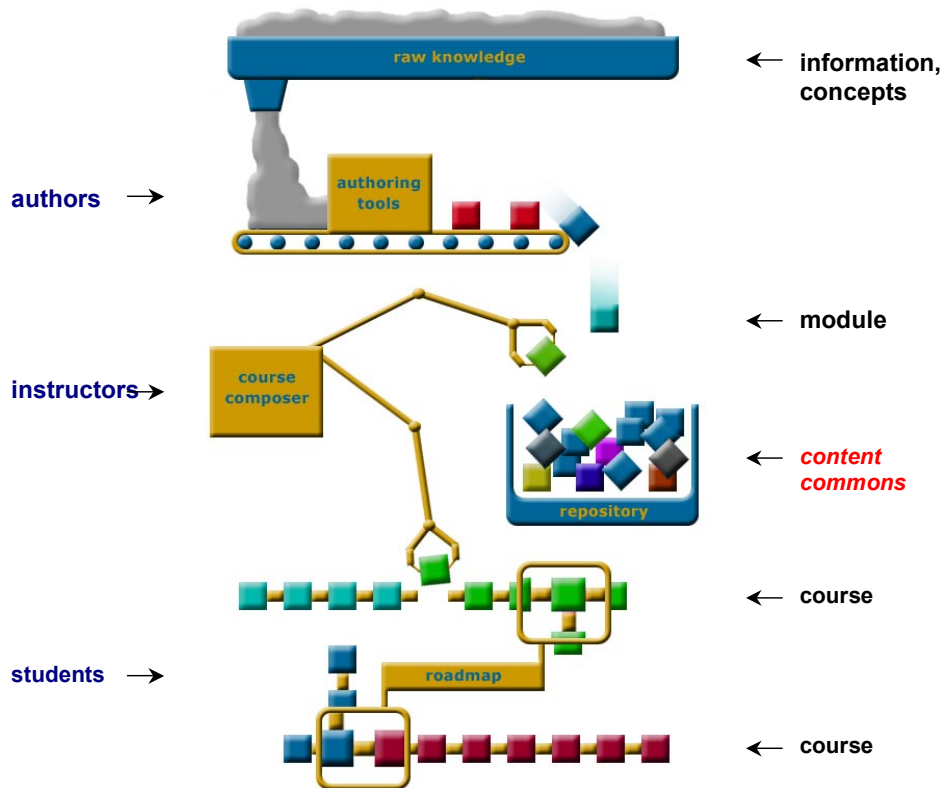


Fig. 1. Connexions as a Knowledge Factory

Facilitate content *reuse*; 4) Foster *community participation* in the commons; and 5) Ensure *sustainability* of this resource into the future. [4] Achieving these goals requires a solid core of enabling technologies that provide a foundation for supporting the needs of Connexions participants. Connexions has been available to anyone to use since the project's inception, but in February 2004 the project announced Release 1 of the system, signaling a maturity and level of functionality available in the software to ensure its robustness and scalability. The Connexions roadmap, course composer/instructor interface, and authoring interface tools, along with a powerful

knowledge repository provide an environment to encourage knowledge sharing and reuse, supporting collaboration and building of communities across geographic, cultural and disciplinary boundaries.

By collaborating both within and across disciplines, communities of authors work together to pool their expertise in creating courses composed of knowledge chunks that are authored by many, with each author receiving attribution for his or her contributions. Information can be modified under an open license to tailor the material for the audiences of learners. This approach invites contributions by authors, whether they are senior or novice, recognizing that each may have valuable insights that will advance overall knowledge and learning. In this environment, the peer review communities collaborate directly with each other, modifying contributions as they go and keeping the knowledge current. Authoring becomes a much simpler task. Rather than write an entire book or article, individuals can write on a single topic in which they are expert. Reuse of knowledge is encouraged and new ideas can readily evolve without waiting for the long pre-publication peer review process to take place. While initially focused on creating customizable courses, the Connexions concept works just as well for the publication of research articles. As new findings are published, the relevant concepts can be picked up by multiple disciplines that may be affected and can be quickly integrated into the curriculum or used in further research activities to promote new discoveries at an increasing pace.

## **2.1 Overall Software Platform**

Connexions has prioritized its software development efforts by identifying the capabilities needed to provide a robust, stable platform for continued growth of the content commons. All software for Connexions is freely available, licensed under open source software licenses. In open source software development, one of the keys to ensuring sustainability of a project is ensuring that there is a community of developers who are interested and active in maintaining the code base. [16,17] The approach Connexions has consistently taken towards software development is to find existing open source software projects that most closely fulfill Connexions requirements and build on top of those existing tools. This helps to provide a stronger base of support, with established communities of open source programmers who support and enhance the existing toolsets. This has proven to be a very effective path for Connexions to follow.

### **2.1.1 Course Roadmap Software**

The Connexions course roadmap provides a persistent guide to instructors and learners using Connexions. Through the roadmap, a course can be opened with a listing of all the modules that are used in that course, ordered and grouped according to the instructor's needs for teaching the material. The course roadmap is a software plug-in to the web browser and is downloaded from the Connexions web site.

The roadmap allows learners to navigate through a course, following links both internal to the knowledge module and external links, such as recommended links the instructor has added, without getting lost. The roadmap provides an "anchor" to show them where they were in the course when they began exploring links.

Learners can add their own annotations to the materials, which are kept private to them. These annotations behave like browser bookmarks, following the student wherever they go. This is a useful feature for students who access their Connexions courses from multiple computers throughout the campus. The Connexions team developed the annotation software from the Annozilla project code base, an open source software project. The enhancements developed to support Connexions were contributed back to the Annozilla project so others needing similar capabilities would not have to recreate them.

Additional functionality of the course roadmap includes an ability to display a course in a different presentation style, view the revision history of the module, print a module as a pdf file, and view metadata related to the module. In addition, users can use the Connexions toolbar that is added to the browser to search for other modules, consult an on-line dictionary, seek help with using the system, and hide/show the roadmap if desired.

At present, Connexions supports all features of the course roadmap in the Mozilla browser and most features in other browsers such as Internet Explorer and Safari on the Macintosh platform. Mozilla is the initial browser for deployment of all software tools, since it is open source and allows us to easily understand how the Connexions software will interface with the browser.

### **2.1.2 Authoring Interface Software**

The authoring interface provides a sophisticated environment to support authors in creating modules to contribute to the Connexions repository. Within the authoring interface, authors can work in their own individual workspace to create drafts of modules prior to submitting them to the repository. They can also work in workgroups with colleagues to collaborate on modules they are developing jointly. Within the authoring interface, the repository can be searched for other modules the author wishes to work with, either to modify them or create a derivative module. Files can be uploaded to an author's workspace or workgroup. A template is provided to collect the metadata associated with the module. Authors can also assign roles to members of a workgroup, indicating whether or not they are the author, maintainer, copyright holder or some combination of these roles. Members of a workgroup can e-mail each other, or add or remove workgroup members. The authoring interface is intended to support the creation, modification, derivation and patching of knowledge modules in the content commons. Prior to finalizing a module, authors can preview how it will look both on the Web and in print. When ready to publish to the content commons, the author can submit the module through the authoring interface

At the time an author decides to create a new module, they are presented with a Creative Commons attribution license that they must agree to. At present, this is the only license accepted by Connexions. It was chosen because it is the most open license and provides a means for continuing to give attribution to the author(s) throughout the derivation process. In the future, other licenses will also be supported.

Authors and instructors are required to have accounts on Connexions. This provides information necessary to associate the author or instructor with materials they are creating, as well as ensures they have agreed to the licensing for the system. In addition to the Creative Commons attribution license that is agreed to at the time a

module or course is created, authors and instructors must agree to the site license for Connexions when they log into the system for the first time.

All of the Connexions content is marked in xml, using the cnxML mark-up specification; until recently, this has been a barrier to widespread utilization of the Connexions platform since authors have been required to understand the nitty-gritty details of inserting xml tag information in the document. Fortunately, more user-friendly editors designed specifically for editing xml documents are now coming onto the market. Their biggest limitations are that they are more suited to forms than to text documents. Connexions is currently in development on an open source WYSIWYG xml editor with Disruptive Innovations (<http://www.disruptive-innovations.com/>) In the interim, Connexions has tailored a commercial editor, called xmlspy, to work with the Connexions platform. Xmlspy provides a robust and easy to use editing environment for xml, allowing users to add the necessary tags to their data without necessarily viewing the details behind the various tags. Additionally, the xmlspy vendor (Altova, <http://www.xmlspy.com/>) provides a free (but not open) version of the editor, called “authentic,” that provides an excellent basic level of editing capability, and will be adequate for many users.

### 2.1.3 Course Composer/Instructor Interface Software

The Course Composer/Instructor Interface allows instructors to work individually as well as collaboratively in workgroups to create courses using modules in the Connexions repository. Working with a course composer template, instructors search through the repository for relevant modules to include in a course. These are then placed in a roadmap for the course that will be the basis for students to navigate through the system.

As with individual modules, courses are licensed using the Creative Commons attribution license. Since the attribution license currently is associated with all the modules in the content commons, this is a very straightforward application of the license across a combination of modules that make up a course. Future copyright licensing of courses will need to consider multiple license types that are associated with the course’s collection of modules, since incompatibilities between the licenses must be considered when assigning a license to a course.

Through the instructor interface, the particular notation to be applied across all modules of information is selected, if appropriate. For example, modules that reference the logic operators “AND” and “OR” do not dictate how those symbols will look when presented. Instructors choose a common notation that will apply across all the logic symbol references that appear in modules that have been collected for the course. Some prefer that these be presented simply as “and,or”, others always want them to look like “& , |,” still others prefer to have them be shown as “ • , + ,” and others insist on “ $\wedge$  ,  $\vee$  .” The actual content of the module simply tags the appropriate element as a logic symbol in xml mark-up, leaving the choice of rendering on the display or print up to the instructor.

Courses can be annotated using the annotation tool. This is one way in which the modules to a course can be customized to meet a specific instructor’s goals if he or she does not wish to create a derivative module. Course level annotations are available for viewing to anyone who is using a Connexions course. This promotes

reuse of modules within differing contexts, where the instructor may want to point out the relevance of the concept to the overall course.

#### **2.1.4 Repository Software**

The Connexions repository software supports searching and management of the content in the Connexions content commons. One of the features of the Connexions repository is that all of the content is available to the popular Web search engines. It is not only the metadata for the knowledge modules that can be searched by Google, Excite, Yahoo and others, but the modules themselves. This has been an additional benefit for Connexions authors and instructors as they receive much more visibility throughout the world when their modules are returned from the general Web searches. Many Connexions modules appear in the top set of search results for a topic. Authors who did not previously know each other have formed new, international collaborations with colleagues working in the same areas as them. These colleagues are providing an additional level of peer review for the authors as they detect mistakes or typos in the content. Many more people have found out about Connexions as a result of modules being returned in Google search results, leading to positive visibility for the project. Connexions modules have also been linked to “best practices” pages, or examples of high quality materials as a result of returns by Web search engines.

## **2.2 Connexions Content Commons**

As new participants in Connexions discover Connexions’ ability to provide a powerful suite of technologies that facilitate authoring, teaching and learning in an open, collaborative environment, their excitement becomes contagious. They tell their colleagues and soon there are new communities involved, growing the overall knowledge base available for use and modification.

The key to sharing knowledge is agreeing to a set of protocols by which it can be shared. In Connexions, this is the use of xml to mark-up the content so that the elements in the materials are easily identified. Xml has begun to emerge as the universally accepted method for identifying meaningful information in content so that it may be effectively searched, used, reused, and displayed with great flexibility.

## **2.3 Legal Issues**

“Open” is not always easily achieved. Current copyright laws automatically “protect” content at the time it is presented for anyone to see. [3,10,11] Connexions has addressed licensing issues in 3 areas: 1) Open Source license of software tools; 2) Open Content Licensing; and 3) Site License for Connexions. The team has worked closely with leaders in open source and open content licensing to address the licensing needs for the project.

### **2.3.1 Open Source License of Software Tools**

As discussed earlier, all software for the Connexions project is released under open source licenses either through existing open source projects or through Connexions

for newly developed Connexions software tools. Through the porting of Connexions to the Plone content management system, the Connexions software development team has contributed significant functionality to this existing open source project and all contributions have been incorporated into Plone's existing open source license [14]

The annotations capability developed for Connexions was released as an update to the open source Annozilla project. As the open source development community continues work on annotation capabilities, Connexions will benefit from the improved annotation capabilities.

The Connexions Roadmap component is an example of software developed specifically for the project. It has an explicit open source license associated with it as part of Release 1 of Connexions.

### **2.3.2 Open Content Licensing**

The project team has proactively addressed licensing issues associated with providing content that is free, modifiable, reusable and easily distributed so that sharing knowledge is easy and desirable. Through our collaboration with Creative Commons, we have provided a framework to allow authors and instructors to associate their materials with a Creative Commons open license that clarifies the rights associated with content. At the time Creative Commons launched in 2002, Connexions was the largest contributor of openly licensed content using the Creative Commons licenses.

Connexions has taken on a roll of educating faculty about what openly licensed content means and why it is beneficial. An initial workshop on the subject was held at Rice in the fall of 2002. A larger, more highly visible workshop on fair use and open content was recently held in June 2004.

At present, the content commons only supports material licensed with the Creative Commons attribution license, which allows full use, including for commercial purposes, provided adequate attribution is made. Various other Creative Commons licenses are available for authors to specify whether they want attribution for the work when it is used, whether the work can be used for commercial purposes, and on what terms the work may be modified. Depending on the choices an author makes in each of these 3 categories, one of 11 machine readable licenses is offered to the author to attach to a work so others will know what they are or are not allowed to do with it. Additionally, Creative Commons provides a means for authors to contribute their works to the public domain. When the copyright is donated to the public, no license is involved. Connexions plans to support multiple content licenses in the future. [2]

### **2.3.3 Site License for Connexions**

As with most Web sites, users of Connexions are bound by the project's site license. The project team worked closely with Lawrence "Larry" Rosen, a renown open source attorney who is the general counsel and secretary of the Open Source Initiative (OSI), and served as its executive director. OSI manages and promotes the Open Source Definition for the good of the community, specifically through the OSI Certified open source software certification mark and program. Larry and Rice's general counsel worked to develop a Connexions site license that would be acceptable to users and maintain the spirit of the open source community. Whenever a user

requests an account on the system (authors and instructors), they must agree to the site license. The license is available for review to all users of the system, whether or not they have an account.

## **2.4 Assessment**

Assessment has been incorporated throughout various parts of Connexions. Many of the knowledge modules in the content commons include elements of assessment that allow learners to test their comprehension of the concepts the module is addressing. This approach of embedded assessment enables students to study a subject until they can be certain of understanding it fully. There is immediate feedback, which helps them correct any misunderstandings quickly and within the context of their studying.

Throughout the software development process, the project has employed Human Computer Interface (HCI) experts to test the usability of the system. Using proven methodologies for conducting usability testing, these tests have identified areas within the interface in need of change and confirmed those that have been well designed. The feedback from the test groups has been used to make modifications to the system.

New, experimental approaches for assessing student learning with Connexions have been used. Concept mapping techniques have been employed whereby students create concept maps that represent the knowledge they are gaining throughout a course. These are compared to the “expert” concept maps of the professor teaching the course. Preliminary use of concept maps as an assessment tool for Connexions-based courses has been very limited in scope, thus it is not yet possible to conclude their effectiveness in measuring student learning. One of the challenges the project has faced is getting instructors to think in terms of the concepts they are teaching rather than the traditional course outlines they are used to following.

## **2.5 Post-Publication Peer Review**

With a view to incorporating “lenses” that will filter the content according to a preferred view (e.g., recommendations of a professional organization or recognized authority), Connexions challenges traditional publishing models by relying on post-publication peer review. While this approach is not new to the software development community where it has proven to be successful in open source software development [16,17], it is new to content. How will someone be able to confirm the validity of the content if anyone can contribute? For peers in a scholarly discipline, it is easy to collaborate and judge materials in their field. After all, they are the peer review process that has already been in place for traditional publishing. For the public at large, however, the availability of trusted lenses for looking at materials in the repository will be important.

### 3 Conclusion

The continued growth of the Connexions Content Commons, with global participation by instructors, learners and authors alike demonstrates the need for providing knowledge in a way that does not lock it up and restrict its dissemination. Connexions has not grown by top down declarations of institutions dictating to their faculty that they will use this technology. Rather, it has been a grass roots movement, starting with the shared knowledge that comprised the first two courses in Connexions in the fall of 2000. As people discover the knowledge, they discover the technology that enables its sharing and collaboration. The excitement of Connexions users is contagious; when someone in a discipline discovers its power, their colleagues come on board and spread the excitement while building the knowledge base. These people find their rewards not in hoping for royalties they'll receive from a textbook that took them years to write, but in being able to openly share their knowledge for free, while continuing to receive credit when their original works are modified and even more widely disseminated.

The Connexions content commons is in its fourth year as an available open repository of shared knowledge. Connexions has been "real" at a time when many others simply espoused a desire to achieve the same goals. Now with over 2,000 original knowledge modules, more than 40 full courses, and a fully supported set of tools available in Release 1, the enabling technology of Connexions is poised for even more significant growth. The content commons is regularly searched by all of the popular web search engines, exposing knowledge and the authors of that knowledge to a wide variety of communities.

Additional enhancements to further lower barriers to adoption of Connexions will support even wider dissemination of the technology. New domains of knowledge are planned for inclusion in the content commons, including knowledge modules and courses in art history. There will be increased participation internationally as Connexions establishes a center of excellence in Europe at the International University of Bremen.

#### Section 1.01 References

1. Anonymous: An open-source shot in the arm? The Economist Newspaper Limited, London, UK (10 June 2004) Available from: [http://www.economist.com/displaystory.cfm?story\\_id=2724420](http://www.economist.com/displaystory.cfm?story_id=2724420)
2. Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities. Berlin (2003). Available from: <http://www.zim.mpg.de/openaccess-berlin/berlindeclaration.html>
3. Boyle, J.: The Second Enclosure Movement and the Construction of the Public Domain in Law & Contemporary Problems. (2003) 63(33), 33-74. Available from: <http://www.law.duke.edu/pd/papers/boyle.pdf>
4. The Connexions Project <http://cnx.rice.edu/>
5. Davis, R.: The digital dilemma. Communications of the ACM (2001) 44(2), 77-83, (ACM Press). Available from: <http://doi.acm.org/10.1145/359205.359234>
6. Harnad S.: Open Access to Peer-Reviewed Research through Author/Institution Self-Archiving: Maximizing Research Impact by Maximizing Online Access. J Postgrad Med

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- (2003);49:337-342. Available from: <http://www.jpgmonline.com/article.asp?issn=0022-3859;year=2003;volume=49;issue=4;spage=337;epage=342;aulast=Harnad>
7. Henry, G.: On-line Publishing in the 21st Century. D-Lib Magazine (2003) 9(10), Available from: <http://www.dlib.org/dlib/october03/henry/10henry.html>
  8. Houghton, J., Steele, C., Henty, M. 2003 "Changing Research Practices in the Digital Information and Communication Environment," Department of Education, Science and Training, Commonwealth of Australia (2003). Available from: [http://www.dest.gov.au/highered/respubs/changing\\_res\\_prac/exec\\_summary.htm](http://www.dest.gov.au/highered/respubs/changing_res_prac/exec_summary.htm)
  9. Krowne, A.: Building a Digital Library the Commons-based Peer Production Way. D-Lib Magazine (2003) 9(10). Available from: <http://www.dlib.org/dlib/october03/krowne/10krowne.html>
  10. Library of Congress, Copyright Office: Copyright Law of the United States of America and Related Laws Contained in Title 17 of the United States Code. (2000). Available from: <http://www.copyright.gov/title17/circ92.pdf>.
  11. Loren, L. P.: The Purpose of Copyright. [Electronic Version] in Open Spaces Quarterly (2000) 2(1). Available from: <http://www.open-spaces.com/article-v2n1-loren.php>.
  12. MIT OpenCourseWare <http://ocw.mit.edu/index.html>
  13. National Science Digital Library (NSDL) <http://nsdl.org/>
  14. Plone <http://plone.org/>
  15. PloS <http://www.plos.org/index.html>
  16. Raymond, E. 1998 "The Cathedral and the Bazaar" *First Monday online journal*. Volume 3 Number 3. 1998. [http://www.firstmonday.dk/issues/issue3\\_3/raymond/index.html](http://www.firstmonday.dk/issues/issue3_3/raymond/index.html).
  17. Raymond, E. 1998 "Homesteading the Noosphere. *First Monday online journal*" Volume 3 Number 10. 1998. [http://www.firstmonday.dk/issues/issue3\\_10/raymond/index.html](http://www.firstmonday.dk/issues/issue3_10/raymond/index.html).
  18. Suber, P.: Timeline of the Open Access Movement. (2004) <http://www.earlham.edu/~peters/fos/timeline.htm>
  19. Wikipedia: The Free Encyclopedia. [http://www.wikipedia.org/wiki/Main\\_Page](http://www.wikipedia.org/wiki/Main_Page)