Peer to Peer Collaboration Using Connexions

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Introduction

The rapid advances in engineering and science require communications that can keep pace with these quickly evolving fields. Researchers can no longer afford to wait for research findings to be published in traditional peer reviewed journals to understand what new discoveries are known and, thus, discern areas where opportunities for breakthroughs are greatest. With the advent of the Internet, communications between colleagues working in common fields has led to increased global collaboration, with data and research easily shared electronically. This increased communication and collaboration is also 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 more frequent breakthroughs occurring internationally.

Within the academy, an additional benefit of sharing knowledge electronically is the ability to include 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, is providing the infrastructure that researchers, authors, instructors and students need to easily facilitate shared communications. Reliance on traditional publishing means has, until recently, been the standard means for continuing to exchange information, even as the collaboration has increased with the availability of the Internet. This paper presents a new framework to better enable rapid knowledge exchanges and collaboration without relying on traditional peer reviewed journals and textbooks to mediate between members of these knowledge communities.

Traditional publication as a means for sharing knowledge

Peer review has always been critical for ensuring that published works are verified as legitimate by the most knowledgeable professionals in a given field. As honest brokers of knowledge, publishers have filled a role in arranging peer review of materials authors would like to publish. Publishers recruit peers in a given discipline without pay, since participating in this process gives the peer reviewers recognition and rewards through the third party institutions with which they are affiliated. This process is long, resulting in delayed publication of new findings. Thus, the rapid sharing of knowledge is compromised. The benefit, however, is that the information can be trusted, having gone through this rigorous process. 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. What is still lacking with Web publications, however, is the assurance of quality that non-experts and third party institutions who are not members of the peer review community need in order to recognize the work as legitimate.

To combat the failure of Web publications that are not affiliated with traditional, recognized publishers to provide the level of legitimacy demanded by non-experts and third party institutions, 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. The price, however, is delayed sharing of knowledge. In the case of textbooks used for teaching, the time and attention to detail required for publication of the textbook exacts a tremendous toll on the author(s), discouraging collaboration and often requiring the author to write about specialties in which s-he is not an expert so that the textbook is comprehensive. Once published, the works cannot be quickly updated because changes would alter the work that has been approved. Rather that taking advantage of the digital environment to keep knowledge current and correct, the electronic publications become frozen, just like their paper counterparts. Not only does rapid knowledge sharing suffer, but students also suffer by increased costs of textbooks and a less than current understanding of their field upon graduation. In engineering disciplines, this can result in their not being competitive for the best jobs in the market.

Making articles available online is only a first step in moving toward the possibilities afforded by the Internet. While publishers have taken a first step by publishing journals electronically, they 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. 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 replace the measure by which the faculty and researchers are judged.

Motivation for collaboration and sharing knowledge
The traditional publication process does little to encourage communities with shared interests to work together in publishing their knowledge. The 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. The ability to share knowledge freely, allowing works to be annotated, discussed, reworked and republished is an advantage of online publication over traditional print publication. Shared knowledge results in new ideas, hypotheses, discoveries: the advancement of knowledge.

Incentives are needed that will encourage widespread sharing of knowledge if we are to overcome the current barriers in place with traditional publications. While some authors will continue to seek the prestige they have come to associate with the publication of their work under the traditional publishing model, many in rapidly changing fields such as engineering will seek widespread recognition by their peers as contributors to their disciplines. These authors know that the likelihood of realizing significant financial gain from publishing the definitive

work in their field is low. Thus, they are encouraged to collaborate and share knowledge rather than protect it.

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. In engineering, incorporating interactive lab simulations with the written materials allows knowledge to be conveyed in a much more meaningful fashion rather than having them be decoupled.

Interactive content not only conveys knowledge in new and exciting ways, it *requires* electronic publication rather than static presentation. Thus, traditional publishers are limited in what they can do with these works. 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. However, more and more, authors are working in the "web" of collaboration, with works not being self-contained; they link to other resources that help to complete the message the author wishes to convey. 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.

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), http://nsdl.org/), while others provide free access to full courses an institution has developed (e.g., Open CourseWare (OCW), http://ocw.mit.edu/index.html).   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 (cnx.rice.edu) has ventured further along the spectrum, 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 most effectively.

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, depicts 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 various concepts to provide a greater view of how topics across disciplines interrelate. Today, Connexions hosts a repository of openly licensed knowledge modules, with over 1,700 modules available for free. The goals of Connexions are to enhance teaching, learning and research by (1) facilitating collaborative development of educational and research content in a broad range of disciplinary communities; (2) providing free access to distributed repositories of educational and research content and curricula; and (3) empowering diverse cultural communities to join in developing knowledge.
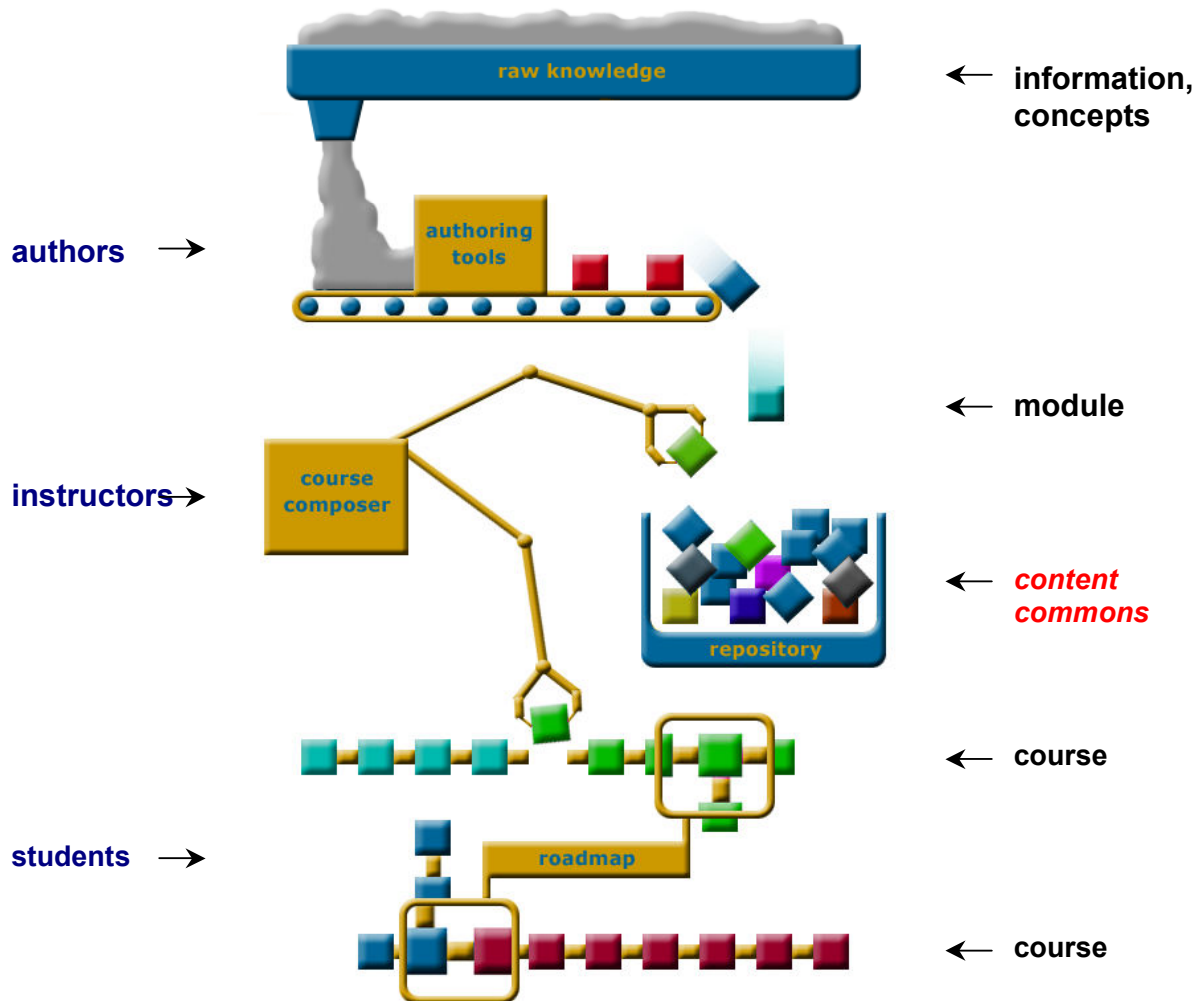
Figure 1: Connections as a Knowledge Factory

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 so that courses, created by stringing together knowledge chunks, 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.

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. Decisions regarding the technical approaches to take for the needed suite of tools also considered long term maintenance and sustainability of the technology platform. 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. 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.

Course roadmap software
The Connexions course roadmap provides a persistent guide to instructors and learners using Connexions for teaching and learning. 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. Figure 2 shows an image of the Roadmap user interface with a course loaded.
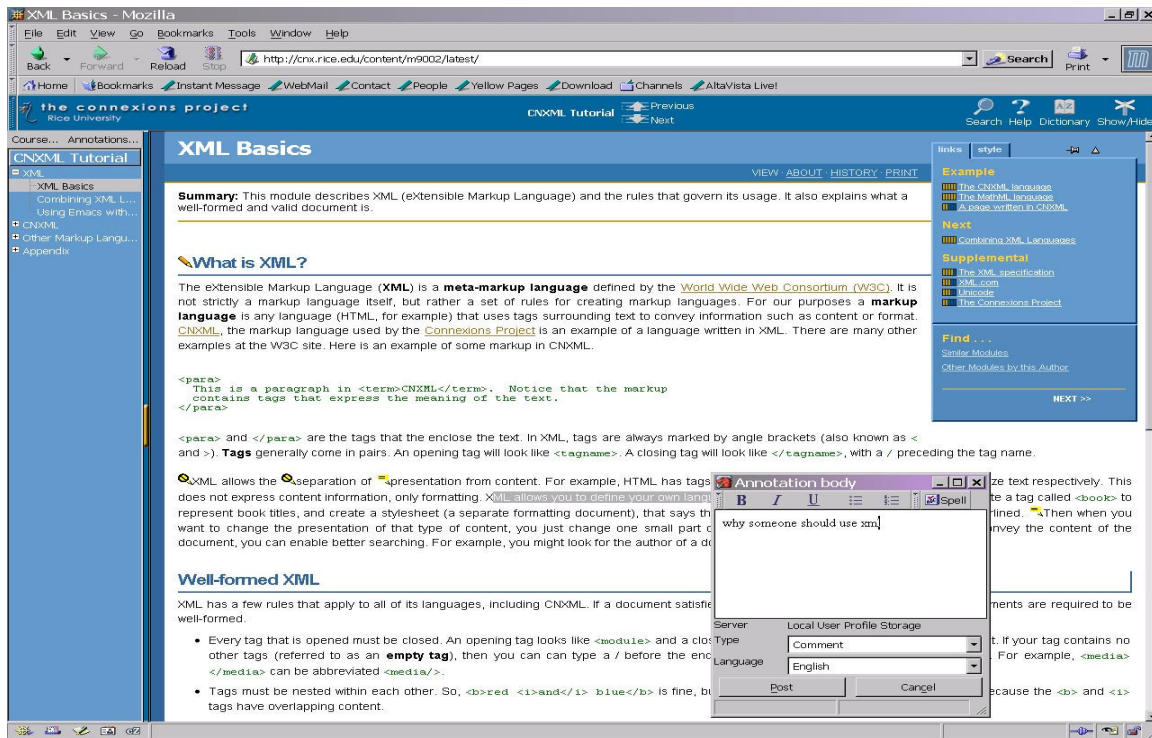
Figure 2: Connexions Roadmap

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 annotations software was developed 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.

Connexions has prototyped a graphical roadmap based on the open source TouchGraph software (http://www.touchgraph.com/). This has been demonstrated on several occasions with one of the Connexions courses on Digital Signal Processing (DSP); it has been viewed favorably and could provide an enhancement in a future release of Connexions. Figure 3 shows the current prototype of the graphical roadmap.
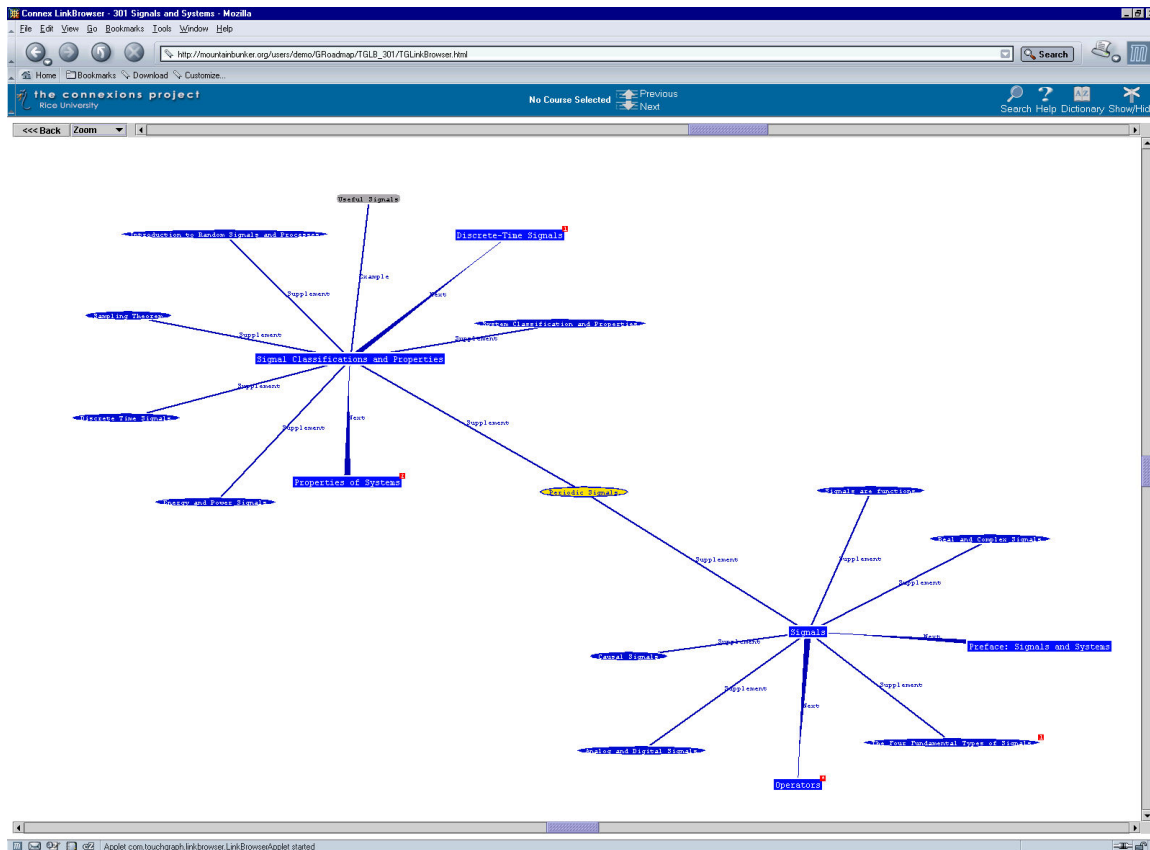
Figure 3: Connexions Graphical Roadmap prototype

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. Following successful deployment in Mozilla, additional work to support other browser platforms is pursued to maximize the impact of Connexions.

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. Figure 4 shows an image of the Connexions Authoring Interface.
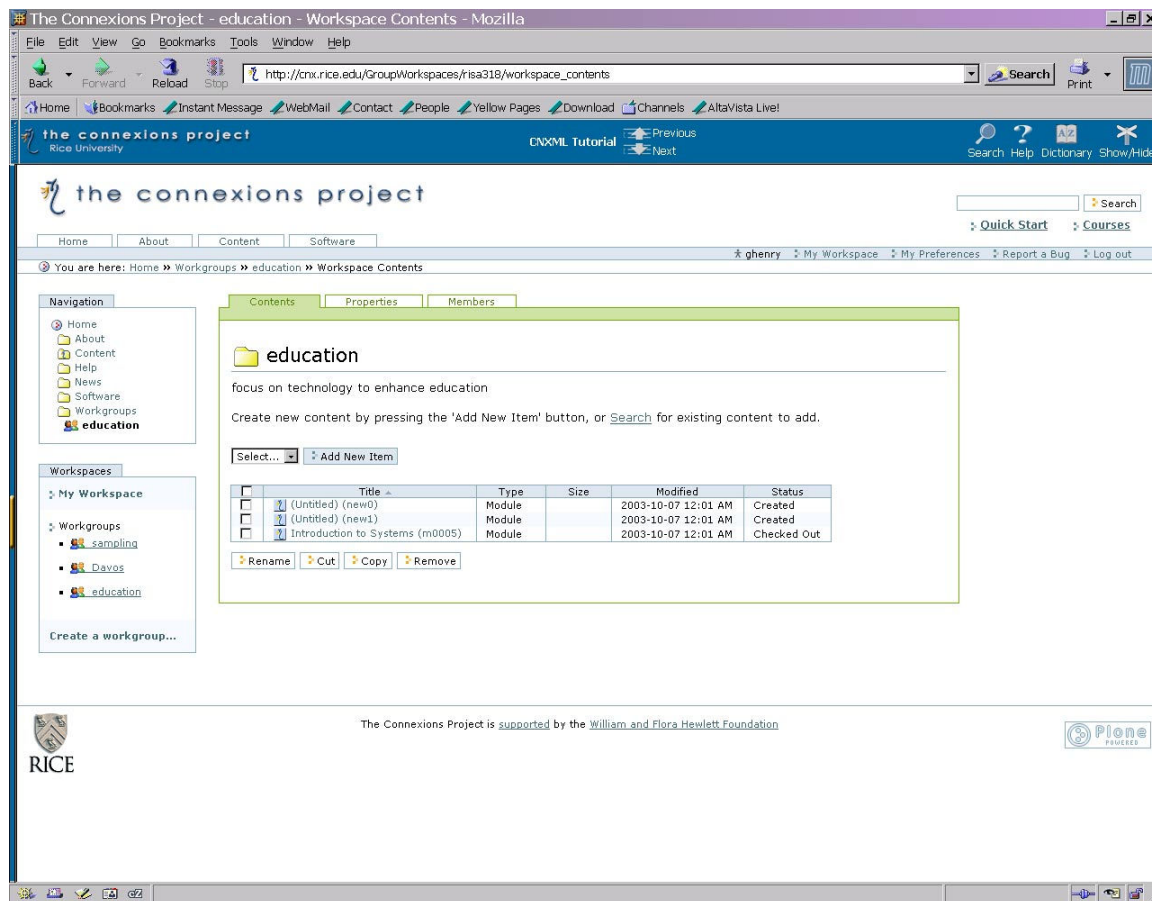

Figure 4: Connexions Authoring Interface

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, additional 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.

Authors currently create modules in an editor of their choosing. All of the content must be marked in xml, using the cnxML mark-up specification; until recently, this has been a major barrier to widespread utilization of the Connexions platform. Standard text editors, such as the

open source Emacs editor, require the author to understand the nitty-gritty details of inserting the tag information in the document, something that only very experienced computer users are willing or able to do. Fortunately, user-friendly editors designed specifically for editing xml documents are now coming onto the market. There is as yet no high quality open-source xml editor, though one is currently in development by Connexions; however, the team has selected and 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.

Course Composer/Instructor Interface software
The Course Composer/Instructor Interface allows instructors to work individually as well as collaborate 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. Some of the modules may require tailoring, so instructors are provided with their workspace and workgroup authoring capabilities when forming courses. Thus, the distinctions between authors and instructors have been relaxed considerably during the past year of Connexions development. Figure 5 shows an image of the Connexions Course Composer/Instructor Interface.

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 "∖ , ⼂ ." 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. There are multiple types of annotations that can be added (e.g. comment, see also, question, explanation, example, change, and advice), each represented by a different icon in the materials. By clicking the icon, a student can view the annotation. If they find the

annotations distracting, they can be hidden so that only the content of the module is visible. 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.
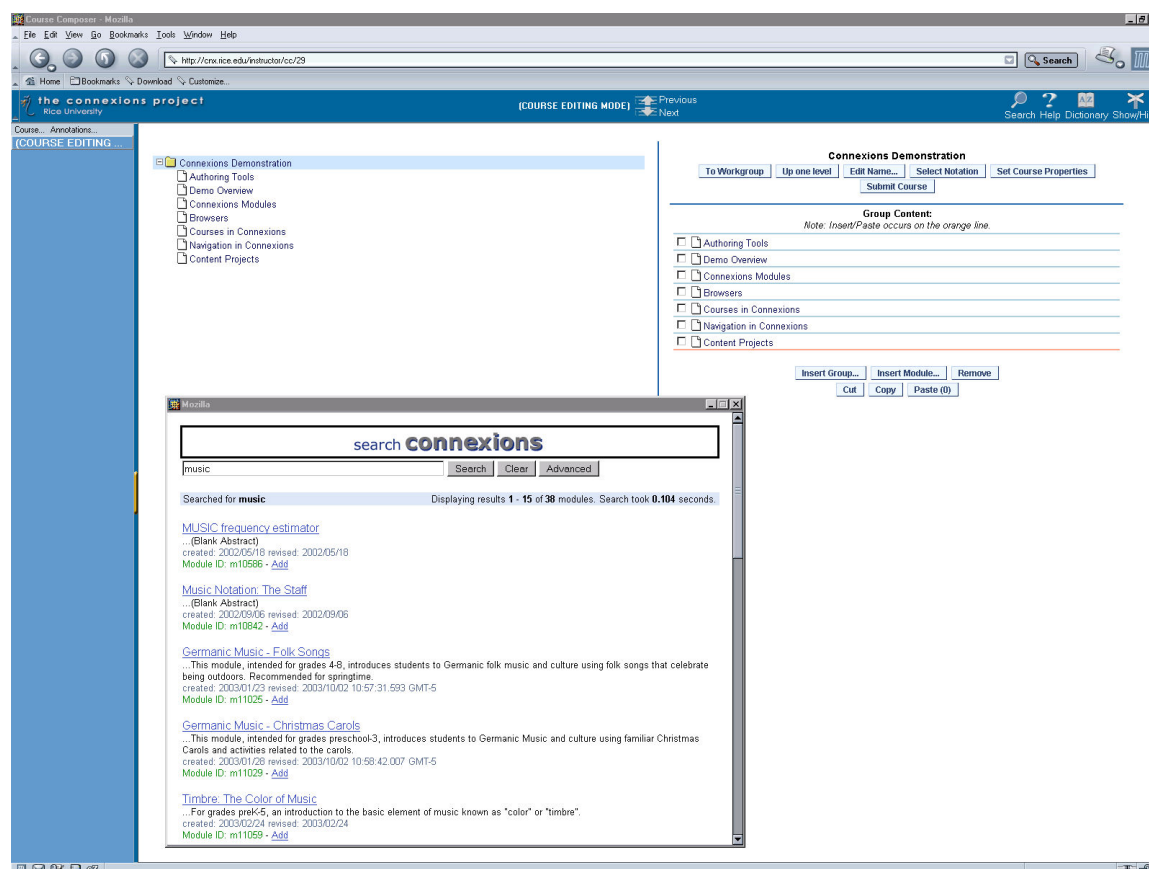

Figure 5: Connexions Course Composer/Instructor Interface

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 for a discipline due to the Web search engines finding the material.

Connexions Content Commons
The majority of content in the Connexions repository is engineering content. This includes lab materials with on-line lab simulations using National Instruments' LabView package to support engineering labs taught using Connexions. 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 and impact. The xml markup that is required can be tedious, especially when using mathematical equations. For content that is not math-intensive, the recommended xmlspy editor provides an easy to use interface for authors, with the verbosity of the tags hidden from the users. For math-intensive content, the Mathematica commercial software tool provides an easy to use environment for math formulas, representing them in content MathML markup. For users who have this software package (it is a widely used application in engineering), it is possible to create the formulas in Mathematica, then copy & paste them into the Connexions editor of choice.

Full courses are taught using Connexions at University of Illinois, Ohio State University, and Cambridge University in addition to Rice. As of the fall of 2003, there were 25 full courses available, with many new courses under development for use in the Spring 2004 semester at several institutions.

Legal issues
"Open" is not always easily achieved. Current copyright laws automatically "protect" content at the time it is presented for anyone to see. Connexions has addressed licensing issues in 3 areas:
- Open Source license of software tools
- Open Content Licensing
- 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.

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 during the past year, the Connexions software development team has contributed significant functionality to this existing open source project and all contributions have been incorporated into the existing open source license adopted by Plone.

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.

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.

Educating faculty about what openly licensed content means and why it is beneficial has been a role of the Connexions team as the project has progressed. An initial workshop on the subject was held at Rice in the fall of 2002. Planning is currently underway for a larger, more highly visible workshop on content licensing in early summer 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 future releases of the system. Support for additional licenses will provider even greater flexibility for contributors who are not comfortable with the attribution license or want to incorporate materials in their modules that are already copyrighted under other licenses.

When an author creates a new module in Connexions, they must first agree to the Creative Commons Attribution license for the module. That license is then associated with the module and displayed whenever the module is displayed. Whether the module is displayed within Connexions or just in a browser as a result of a Web search, the license will be available letting users know that they are free to modify the material, distribute it, and use it for commercial purposes provided they attribute the author each time.

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 reviews and approves major open source licenses, several of which were written by Larry. 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. Only those with accounts must explicitly acknowledge agreement to the site license.

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 if 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 the services of a Human Computer Interface (HCI) expert 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 in support Release 1 of the software.

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. The results have been informative. 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 greatest challenges we have faced is getting professors to think in term of the concepts they are teaching rather than the traditional course outlines they are used to following.

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, 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.

Conclusion

In the fall of 2000, two faculty members in the Electrical and Computer Engineering (ECE) Department at Rice University each taught a course they had been teaching for many years: Fundamentals of Electrical Engineering and Introduction to Physical Electronics. But something was radically different that fall. For the first time, Connexions was introduced through these two full Connexions courses. The response to the instructors from their students was overwhelmingly positive. Their colleagues in ECE came on board and began developing their courses in Connexions. Though the toolsuite in the fall of 2000 was not nearly as fully functional as it is today, it provided those early adopters with an enabling and deeply empowering technology that supported a means for them to share their knowledge, evolve it, collaborate with their colleagues, quickly update courses with new advances in the field, and show students how concepts they learn about across their courses are related to each other.

The original 150 knowledge modules that comprised the two ECE courses lived in the Connexions content commons and were openly available to the world for free. Connexions authors began to receive e-mails from engineering faculty and professionals around the globe asking them questions about their topics and suggesting ways to further clarify explanations they had written describing a concept. Through this exposure and exchange of knowledge, new collaborations have been formed with the original Rice faculty members who authored the Connexions modules. 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 these two courses. 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 1,700 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. Connexions has been cited in numerous publications throughout the past year, including *Wired* and the *Chronicle of Higher Education*, further signifying its rise in popularity. The Connexions site is linked in numerous locations across the web as a site for high quality educational content. Without any significant effort at publicity, the project is receiving recognition as a unique and empowering resource for authors, instructors, and learners around the globe.

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.

Four years ago, a faculty member at Rice University who cared very much about how well his students were learning had a vision for enabling a richer teaching and learning experience that would benefit everyone around the globe and cost them nothing. Today Dr. Richard Baraniuk's dream is a successful reality with Connexions. Thanks to funding from the Hewlett Foundation, Connexions has enriched the world, supporting the growth of an open commons of content that unites communities in freely sharing their knowledge to create a more enlightened society.

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