Modular Object-Oriented Dynamic Learning Environment: What Open Source Has To Offer

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Open source online learning environments have emerged and developed over the past 10 years. In this paper we will analyze the underlying philosophy and features of MOODLE based on the theoretical framework developed by Hannafin and Land (2000). Psychological, pedagogical, technological, cultural, and pragmatic foundations comprise the framework and represent the major points of our analysis. This paper is intended for instructional designers, distance education specialists, K-12 and college instructors who may want to add an online component to their courses.

> As we enjoy great Advantages from the Inventions of others we should be glad of an Opportunity to serve others by any Invention of ours, and this we should do freely and generously.
>
> *~ Benjamin Franklin*

Introduction

Benjamin Franklin's philosophy resonates in the recent advent of *open source* software. The term "open source" refers to computer programs or operating systems for which the source code is publicly available. (Johnson-Eilola, 2002) The definition further explains that inherent in the open source philosophy is the freedom of a distributed community of programmers to modify and improve the code (Perens, 1999).

Open source software promotes the use of technologically-neutral, non-proprietary tools and formats, which allow for wide-spread access. According to the Open Source Initiative website (2004), the major reasons for utilizing open source software include free distribution, freedom to modify the software to meet individual needs, cross-platform compatibility and universal accessibility, and active collaboration to improve design. These factors bear a special significance in an educational setting. As Terry Vessels (2004) puts it:

> …Educators have been called upon throughout history to combat censorship imposed by various powers over the flow of information. The censorship being applied today comes in the form of licenses that lock away the tools to build the information age and laws that limit fair use in ways that are unprecedented in the modern era (¶ 2).

The open source movement has already had a significant impact in the business world (Wheeler, 2003), and is now drawing the attention of educators around the globe. Distance education is at the forefront of using and creating open source applications in education.

Current advances in open source online learning environments are a response to the shortcomings of commercial products like WebCT and Blackboard. One such weakness is a lack of flexibility in designing and adding customized learning modules. With commercial products one can only include elements that the software designers deemed necessary when they developed the program. With an open source learning environment it is possible to download and use any learning module one might find on any open source software website. This opens almost limitless capabilities for the user to customize the application by choosing from a variety of options for e-mail, discussion boards, chat, online quizzes, and all the other elements one might want to include.

Further, as the open source definition suggests, the actual code can be modified and improved to meet individual needs. So, if the user decides that an open source module he or she found is *almost* perfect, the code can be modified to meet his or her needs. Look, feel and functionality can all be changed since the code can be easily accessed and modified.

As to pricing of commercial products, "companies are moving toward selling campuswide access to software, and toward setting prices based on the number of students each college enrolls." (Young, 2002) According

to Young, "… the company's [WebCT] current software costs $3,000 to $30,000 annually, depending on the size of the institution and the level of use of the software." This is particularly important with seemingly continual decreases in federal and state appropriations for higher education. All open source software, on the other hand, is available free of charge to anyone who wants to use it.

Shortcomings of commercial distance education software have prompted the development of a number of open source online learning environments such as MOODLE, EduCreate, Covidia, and LogiCampus. Concurrently, the open source concept has developed to the point that even the tools used to create such systems are open source. For example, most of this software is written in Hypertext Preprocessor (PHP) an open source alternative to commercial scripting languages and make use of open source relational database systems like MySQL. They can be installed on almost any web server—the most popular being Apache (again, open source). One open source online learning environment, Modular Object-Oriented Dynamic Learning Environment (MOODLE) is a highly usable, reliable, and functional alternative to popular commercial products like WebCT and Blackboard. Developed by Martin Dougiamas, a PhD student in Computer Science and Education at Curtin University of Technology, Australia, this learning environment provides the considerable flexibility inherent in open source software for designing and administering Web-based courses to meet the individual needs of online educators. It was specifically developed to address the aforementioned shortcomings of commercial online learning environments—which he had used and supported in his own teaching and as a technician working with faculty. In his own words:

> … It started in the 90's when I was a webmaster at Curtin University of Technology and a system administrator of their WebCT installation. I encountered many frustrations with the WebCT beast and developed an itch that needed scratching – there had to be a better way (no, not Blackboard :) (Dougiamas, 2004, ¶ 2).

Analysis of MOODLE

Dougiamas decided to create his own online learning environment in the open source format and allow the open source community to help develop and refine his ideas. MOODLE was designed to support and promote users interested in developing constructivist, student-centered learning environments (Dougiamas, 2004). To examine this claim, we conducted an analysis of MOODLE using a framework developed by Land and Hannafin (2000) which was initially designed as a guide for developing constructivist learning environments. According to the authors, "Learning environments, directed as well as constructivist, are rooted in five core foundations: psychological, pedagogical, technological, cultural, and pragmatic" (Hannafin & Land, 1997). Figure 1 highlights the five components of these core foundations as applied to the design of student-centered learning environments.

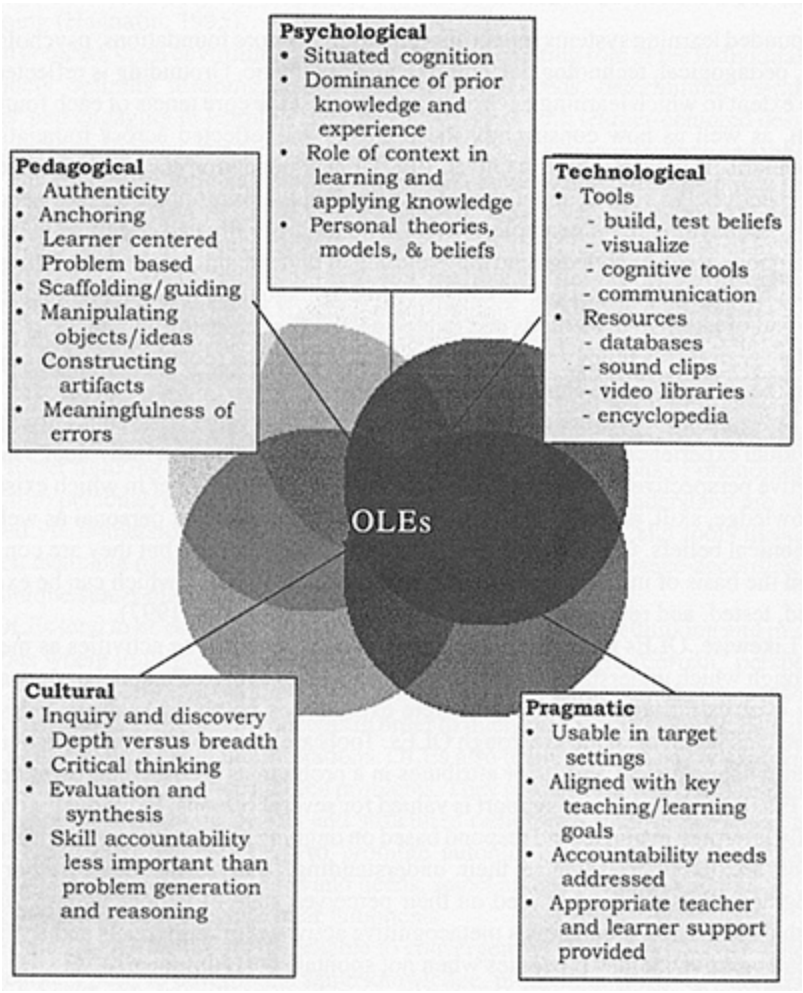

Figure 1: Five core foundations of student-centered learning environments (Hannafin & Land, 1997)

In the remainder of the paper we will relate each of Hannafin and Land's core foundations to the underlying philosophy and principles that guided the development of MOODLE.

Psychological Foundations

Psychological foundations address research, theory and practice associated with how people think and learn. Our examination of the program shell and standard MOODLE learning modules reflect the designers' use of several important considerations from cognitive psychology:

Situated cognition suggests effective learning should involve immersing students in authentic activity and culture in a real-world learning context. (Brown, Collins, & Duguid, 1989). Relevance is enhanced through interconnected, embedded engagement with interesting and complex tasks situated in an authentic context. Situated learning integrates four critical factors that maximize student learning potential: content, context, community, and participation (Stein, 1998). MOODLE learning modules allow instructors to set up complex, ill-defined and authentic tasks in real-life contexts, and assign roles for students to assume in the solution of these problems. For example, the *Workshop* module allows students to collaborate on the design of possible solutions to an authentic problem and peer assess the suggested solutions. The instructor might decide to have students work individually or in groups to determine where to build an alternate route to help alleviate traffic accidents at a specific intersection. In the *Resource* module the instructor can scaffold the activity by providing area maps, different perspectives on the problem (e.g. interviews with Department of Transportation experts), and sample solutions devised by other states or counties. Students can brainstorm possible solutions in *Chat* or *Discussion* forums, then present their alternate routes

via the *Workshop* module, which allows for peer assessment. Thus, learners will compare and contrast their solutions and select the best one based on the group discussions.

Cognitive flexibility is defined as "the ability to adaptively re-assemble diverse elements of knowledge to fit the particular needs of a given understanding or problem-solving situation" (Spiro & Jehng, 1990). This theory focuses on learning in complex and ill-structured domains—which represent many real-life situations. "A central claim of cognitive theory is that revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition" (Spiro, Feltovich, Jacobson, & Coulson, 1991). One of the major metaphors employed by the theory is that of a "… criss-crossed landscape, with its suggestion of a non-linear and multi-dimensional traversal of complex subject matter, returning to the same place in the conceptual landscape on different occasions, coming from different directions" (Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger 1987; Wittgenstein, 1953). MOODLE supports the "criss-crossing of the conceptual landscape" through the Glossary learning module–a unique feature that allows users (both students and instructors) to create an online hypertext-based dictionary that is created on the fly and updates automatically to all content in the course or even throughout the entire portal. This module allows users to consult the glossary dynamically while navigating through the lesson content, assignments, or even discussion postings, but, perhaps more importantly, students take ownership for their learning as they actively construct a richer, more complex and sophisticated learning environment.

Pedagogical Foundations

Pedagogical foundations include the instructional practices that the designers use. They are grounded in theories of learning and reflect the teaching strategies with which they are aligned. MOODLE developers have explicitly stated that the design of the software is grounded in constructivist and constructionist instructional principles. In the following paragraph, Dougiamas (2004) discusses the importance of pedagogy and encourages educators to adopt the constructivist methodology:

> Once you are thinking about all these [pedagogical] issues, it helps you to focus on the experiences that would be best for learning from the learner's point of view, rather than just publishing and assessing the information you think they need to know. It can also help you realise how each participant in a course can be a teacher as well as a learner. Your job as a 'teacher' can change from being 'the source of knowledge' to being an influencer and role model of class culture, connecting with students in a personal way that addresses their own learning needs, and moderating discussions and activities in a way that collectively leads students towards the learning goals of the class. (¶ 13)

Constructivism implies that the learner links new information with existing and future-oriented knowledge in unique and meaningful ways (McCombs & Whisler, 1997). Social constructivism, a branch of this theory, emphasizes the value of knowledge that is built socially in a learning community. Pioneered by theorists like Vygotsky (1978), this paradigm argues for the importance of culture and context in forming understanding. Learning is not a purely internal process, nor is it a passive shaping of behaviors. Vygotsky favored a concept of learning as a social construct which is mediated by language via social discourse.

MOODLE promotes social discourse in learning through the synchronous and asynchronous communication modules described above. Internal support for introducing groups within a class of students in the learning environment is built into the program. Students can form cohorts themselves or the instructor can moderate this process. Within a cohort students work cooperatively and engage in a more individualized interaction with one another. Later, cohorts can share their perspectives in a whole class discussion and continue the learning process as a unified group. Although the program supports this type of instruction, the art of combining individual activities with cohort-based or whole-class activities is one of the factors that reflect the teaching skills of the instructor. An instructor may choose to integrate a discussion forum, chat or even a private two-way dialogue into any learning activity of the course. *Wiki* is the module that gives students and instructors the opportunity to collaborate on the design of hypertext that represents the knowledge constructed socially by the learning community of an individual class. A community of graduate students, for example, can thus work together on a literature review for a specific topic. The document is started when a student makes the first text entry. Other students modify this document to develop the ideas for the literature review. The system keeps track of each modifications and both students and instructor have the opportunity to see how the document developed over time, and who and how each person

contributed. Younger learners might enter and revise class notes in a group *Wiki*, compare and revise the notes as a class, and create a useful resource for each other and for future students.

Constructionism (as opposed to Constructivism) asserts that that knowledge acquisition is particularly effective when constructing something for others to experience. Papert (1991), who started developing this concept in the 1980s, asserts that constructionism "…shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe." Constructionism stresses the importance of building external artifacts as a means to more effectively construct and represent the inner knowledge structures. The importance of learning through design is supported by the research on children's development of strategies and collaboration in video game design, building and learning with programmable bricks (Kafai & Resnick, 1996). In addition to the *Glossary* and *Wiki* examples provided earlier, MOODLE supports the construction of artifacts by allowing learners to present and share their knowledge in a variety of different formats, including multimedia and hypertext. These products can then be shared with others through *Discussion Forum*, *Resource* or *Assignment* modules. Further, as described above, the *Workshop* module promotes social construction of knowledge artifacts by allowing students to collaborate on the possible solutions to ill-structured real-world problems and evaluate them in the peer assessment activity.

Technological Foundations

Technological foundations affect how media can support, limit, or improve the pedagogy of the learning environment. According to Land and Hannafin (2000), "… technology can control the pacing and chunking of information where cognitive load limitations are assumed…"

MOODLE supports the pedagogy of the learning environment through its interactive, collaborative and reflective modules. For example, the Journal module allows the instructor to ask the students to reflect on a particular topic, and edit and refine their answer over time. This activity promotes self-assessment, critical thinking, and metacogntition. Learning journals entice students to think in unconventional ways (Fulwiler 1987) and provide an opportunity to both develop and capture reflection in the learning process (Moon, 1999).

Although the flexibility of hypertext systems is powerful, it may result in disorientation problems (Theng, 1997) and information overload (Niederhauser, Reynolds, Salmen & Skolmoski, 2000). The MOODLE shell provides a framework for presenting modules that accounts for these potential problems. It allows to structure and control the presentation of the learning material and decrease the risk of the "lost in hyperspace" problem (Boyle & Encarnacion, 1994). For example, each page of the portal has a quick-jump drop-down menu that allows users to navigate the system more efficiently. Users may also use the personalized navigation bar at the top of each page, which tracks and shows the history of previously viewed pages for each specific user. Extraneous cognitive load often occurs when instructional materials require learners to use cognitive resources to search for specific information without providing any scaffolds or quick and easy access to relevant resources (van Merrienboer, Kirschner, Kester, 2003). Information overload of learners is reduced through built-in support for adaptive hypertext navigation (Hook, 1997). Navigation in MOODLE is further enhanced via the use of the *Latest News* section, which allows instant access to the most recent discussion postings, news entries and assignments. A similar function is performed by the Calendar module that highlights the upcoming events, due dates and other information through simple mouse rollovers.

A major strength of using MOODLE lies in the inherent nature of open source software which promotes customization. With only a basic knowledge of web scripting one can add almost any open source stand-alone application to customize an online learning environment to meet individual needs. For example, more than half of the modules, visual themes, and administration features available in the current version of the program have been added by different members of the open source community. This brings us to the discussion of another important foundation of learning environments – the cultural aspect of design.

Cultural Foundations

Cultural foundations tend to reflect the prevailing values of a learning community. For instance, one might find particular values such as back to basics, interdisciplinary learning, or global society in a given learning environment. (Land & Hannafin, 2000)

The central ideas in the MOODLE culture are collaboration, sharing and community. They are represented in Dougiamas' (2004) discussion of social constructivism, one of the four major concepts in the underlying philosophy of MOODLE:

> [social constructivism] extends the above ideas into a social group constructing things for one another, collaboratively creating a small culture of shared artifacts with shared meanings. When one is immersed within a culture like this, one is learning all the time about how to be a part of that culture, on many levels. (¶ 9)

Virtual community is defined as a community of people sharing common interests, ideas, and feelings over the Internet or other collaborative networks (Rheingold, 2000). Members of a learning community also share the meanings that they make of the learning material. Social exchanges by individual students are an important part of the group interaction and learning. They help build a sense of trust and respect among community members (Lally & Barrett, 1999). Students in the MOODLE learning environment form a cultural community by interacting in synchronous and asynchronous discussion modules, *Journal* and the collaboration tools like *Workshop*, *Wiki* and *Glossary* discussed earlier.

Another aspect of community building associated with MOODLE involves those who are working to develop, refine, and support advancement of the program. The collaborative nature of designing and supporting open source applications like MOODLE reflects the important social aspect of software development and knowledge construction by integrating the diverse perspectives and expertise of the members of the international community working together to improve the quality of the software. The community of MOODLE developers and users bring multiple perspectives and skills and share their views on online learning in MOODLE discussion forums. This international collaborative effort results in a truly socially constructed design process, which enhances the quality of the software from both the pedagogical and technological perspective. For example, Williams Castillo, "a curious developer" from Caracas, Venezuela, contributed to this open source project by designing the Glossary module. He also maintains a discussion forum on creative uses of the Glossary. Further, the community works collaboratively to provide technical support for all of its members.

Pragmatic Foundations

As the name suggests, these foundations are concerned with doing a reality check. How does the learning environment correspond to the needs of target audiences? What are the benefits, and what are the limitations?

MOODLE is an open source online learning environment that is developed for the administrators of web-based courses for K-12 and university instructors. The system is efficient and features cross-platform compatibility and a low-tech browser interface. A highly relevant aspect of MOODLE for educators is that it is available as a free download on the Internet and can be installed in an hour. Even though one can administer the installation of MOODLE with just a basic knowledge of web interfaces, one should probably have experience managing database-driven dynamic websites.

With the software installed the creation and management of the learning environment can be performed by a person with limited technological expertise. MOODLE's creators realize that educators are not high-end developers and therefore all the administration is performed through a simple, intuitive graphical user interface (Figure 2). Help buttons are included for every component of the administration menu and provide guidance for novice users of the system.

Most text entry areas in MOODLE such as resources, forum postings, assignments etc. can be edited using an embedded WYSIWYG (What You See Is What You Get) HTML editor. The administrator (instructor) can allow or prohibit students to modify specific parts of the course, like journal entries. Further, MOODLE courses can be categorized and searched, allowing one MOODLE installation to support thousands of courses and function as a campus edition. Plug-in activity modules can be added to existing MOODLE installations and enhance the existing structure of the courses. Customizable themes allow the administrator to customize the site colors, fonts, layout, and other features to suit individual needs. MOODLE language packs allow full localization to 43 languages. Even the language packs can be easily edited using a built-in web-based editor. [Insert Figure 2 about here]

> Technical support is freely available on the Web and is provided by MOODLE developers and users through discussion forums and Frequently Asked Questions section. Each learning module is supported by a separate discussion forum containing tips and tricks, teaching strategies, learning standards, course formats, and advice on how to build a strong learning community.

Conclusion

Open source software has become increasingly popular in many areas. One such application, MOODLE, provides a constructivist learning environment that makes a significant contribution to enhance web-based learning.

As this paper demonstrates, the design of MOODLE integrates general principles of constructivist learning and provides an online learning context that supports student-centered pedagogy. This system is grounded in

situated cognition and cognitive flexibility theory that provide the opportunity for an instructor to create a constructivist and constructionist environment to enhance teaching and learning. The capabilities to design student-centered learning are embedded in MOODLE and its modules; however, it is ultimately the responsibility of the instructor to make good use of them.

The MOODLE project indicates the growing interest of educators and open source programmers in joining their efforts to improve the quality and reduce the cost of education. Since it is distributed under the General Public License, MOODLE can be easily modified to meet individual needs. Further, development, customization, and support are all completed as part of the community effort to improve online teaching. This open source application provides an effective and cost-efficient alternative to expensive commercial software packages for those interested in joining the movement to provide high quality constructivist-based educational experiences in the online environment.

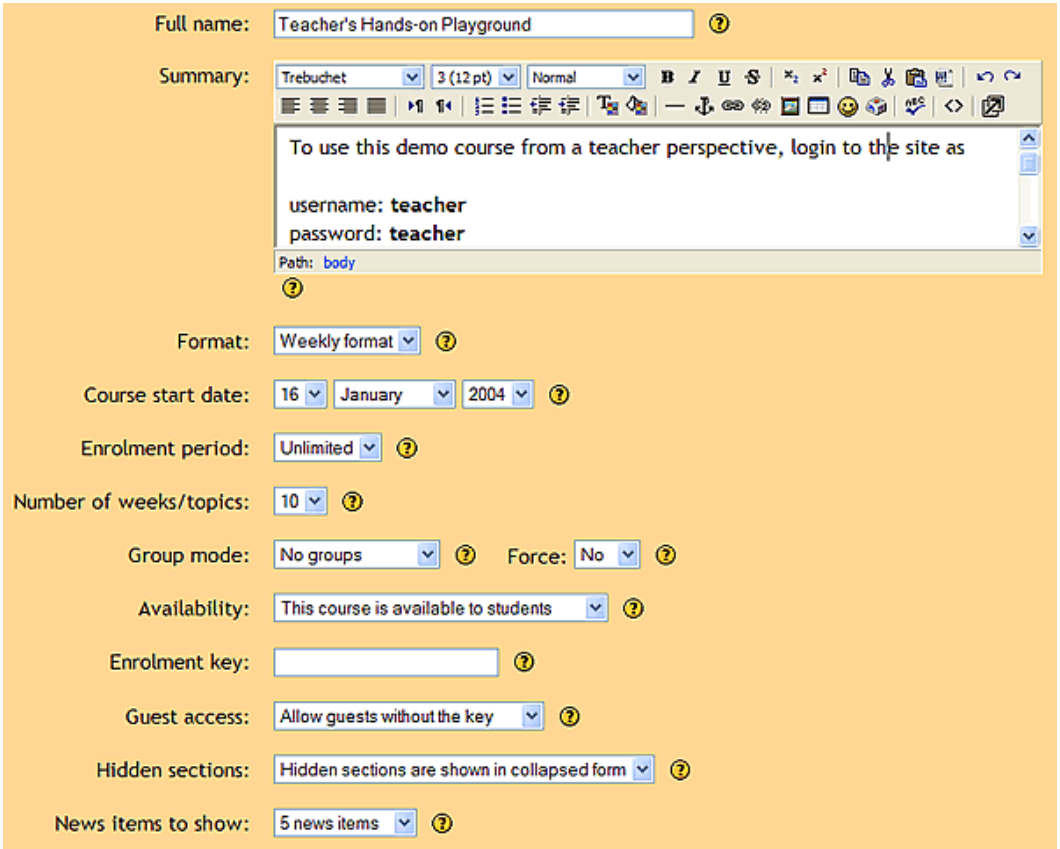

Figure 2: Screenshot of MOODLE course administration page

References

Beyer, B. K. (1991). Teaching *thinking skills: A handbook for secondary school teachers*. Boston, MA: Allyn and Bacon.

Boyle, C., & Encarnacion, A. (1994). Metadoc: An adaptive hypertext reading system. *User Modeling and User-Adapted Interaction, 4*, 1-19.

Brown, J.S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning. *Education Researcher, 18(1),* 32-42.

Dougiamas, M., Taylor, P. (2003). MOODLE: Using learning communities to create an open source course management system. *Proceedings of the EDMEDIA 2003 Conference, Honolulu, Hawaii*.

Fulwiler, T. (1987) *The journal book*. Portsmouth, NH: Heinemann.

Hannafin, M.J., Hannafin, K.M., Land S.M., & Oliver K. (1997). Grounded practice in the design of learning systems. *Educational Technology Research and Development, 45*(3), 101-117.

Hannafin, M.J., & Land, S.M. (1997). The foundations and assumptions of technology-enhanced, student-centered learning environments. *Instructional Science, 25,* 167-202.

Hannafin, M.J., Land, S.M., & Oliver K. (1999). Open learning environments: Foundations, methods, and models. In C. Reigeluth (Ed.) *Instructional Design Theory and Models (Vol. 2)* (p.122). Mahwah, NJ: Lawrence Erlbaum Associates.

Hook K. (1997). Evaluating the utility and usability of an adaptive hypermedia system. *Proceedings of the 1997 International Conference on Intelligent User Interfaces,* 179-186.

Johnson-Eilola, J. (2002). Open source basics: Definitions, models, and questions. *Proceedings of the 20th Annual International Conference on Computer Documentation,* 79 – 83.

Kujawa, S., & Huske, L. (1995). *The strategic teaching and reading project guidebook*. Oak Brook, IL: North Central Regional Educational Laboratory.

Lally, V., & Barrett., E. (1999). Building a learning community online: Toward socio-academic interaction. *Research Papers in Education, 14(2),* 147-163.

Land, S.M., & Hannafin, M.J. (2000). Student-centered learning environments. In D. Jonassen (Ed.) *Theoretical Foundations of Learning Environments* (pp.1-19) Mahwah, NJ: Lawrence Erlbaum Associates.

McCombs, B. L., & Whisler, J. S. (1997). *The learner-centered classroom and school***.** San Francisco, CA: Jossey-Bass.

MOODLE Philosophy. (2004). In MOODLE Documentation. Retrieved April 7, 2004, from http://moodle.org/doc/?file=background.html

Moon, J, A. (2000). *Reflection in learning & professional development: Theory and practice*. Kogan Page.

Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research, 23,* 237-255.

Open Source Initiative. (2004). Retrieved April 8, 2004 from http://www.opensource.org

Papert, S., & Harel, I. (1991). *Constructionism*. Ablex Publishing Corporation.

Perens, B. (1999). The open source definition. In C. Dibona, S. Ockman, and M. Stone (Eds.), *Open sources: voices from the open source revolution.* O'Relly Press.

Rheingold, H. (2000). *The virtual community: Homesteading on the electronic frontier*. The MIT Press.

Spiro, R.J., Vispoel, W., Schmitz, J., Samarapungavan, A., & Boerger, A. (1987). Knowledge acquisition for application: Cognitive flexibility and transfer in complex content domains. In B.C. Britton (Ed.), *Executive control processes.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Spiro, R.J., & Jehng, J.C. (1990). Cognitive flexibility and hypertext: Theory and technology for non-linear and multidimensional traversal of complex subject matter. In D. Nix and R.J. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology* (pp. 163-205). Hillsdale, NJ: Lawrence Erlbaum Associates.

Spiro, R.J., Feltovich, P.L., Jacobson, M.J., & Coulson, R.I. (1991). Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. *Educational Technology, 31(5),* 24-33.

Stein, D. (1998). Situated learning in adult education. *ERIC Digest, 195*. Retrieved April 10, 2004 from http://www.ericfacility.net/databases/ERIC_Digests/ed418250.html

Theng Y. L. (1997). Addressing the 'lost in hyperspace' problem in hypertext. *PhD Thesis,* School of Computing Science, Middlesex University.

Van Merrienboer, J.J.G., Kirschner, P.A., & Kester,L. (2003). Taking the load off the learner's mind: Instructional design for complex learning. *Educational Psychologist, 38,* 5-13.

Vessels, Terry (2004). Why should open source software be used in schools? Retrieved April 15, 2004 from http://edge-op.org/grouch/schools.html

Vygotsky, L. (1978). *Mind in society: The development of higher mental processes.* Cambridge, MA: Harvard University Press.

Young J.R. (2002). Pricing changes by Blackboard and WebCT cost some colleges more – much more. *The Chronicle of Higher Education*. Retrieved April 7, 2004 from http://chronicle.com/free/2002/03/2002031901u.htm

Wheeler, David (2003). Why open source software / free software (OSS/FS)? Look at the numbers! Retrieved April 5, 2004 from http://www.dwheeler.com/oss_fs_why.html

Wittgenstein, L. (1953). *Philosophical investigations*. New-York: Macmillan.