Self-Organizing Social Learning Through the Monastery Gates

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Abstract
An example of an emergent, self-organizing on-line social learning system is available at the *PerlMonks* site at http://perlmonks.org/. Perl is a scripting language commonly used to as an interface between databases and web pages. Provided in this paper is a review of principles of emergent, self-organizing systems from a perspective of learning systems as well as case study of *PerlMonks* as self-organizing eLearning.

Key Terms
Self-organizing, learning environment, eLearning, systems, emergence, social learning

Introduction
The increasing adoption of eLearning is a source of substantial innovation in the education sector worldwide. More compressed eLearning product cycles than ever possible before are now available through frequent, regular advances in Internet technologies and through deployment of sophisticated, interactive network resources for eLearning (e.g., video over IP, streaming audio, synchronous meeting software, group collaboration software, just to name a few).

Progress in eLearning technology is occurring at the same time that structural changes in the education industry are visible on the horizon. The traditional educational institution, with its homey connotation as a staid public service, is evolving into a highly organized industry emulating the same strong competitive and innovative instincts and features that characterize private ventures and offerings.

Much current effort is spent on making eLearning systems perform as more traditional learning delivery systems, only more efficiently and at a distance. So, innovations in "command-and-control" instruction focus on the attainment of learning objectives using techniques that are adapted from classroom methods to distance technologies. For instance, lectures are mounted as streaming media on the web. Instructional materials, formerly distributed as print materials, now are distributed from a web site as, say, Adobe PDF files. Assignments, formerly submitted to instructors directly, now are submitted in electronic "dropboxes," where they are scored and returned, again, electronically to students. In general, though, students still are told what and how to learn. An external authority, often one teacher, assesses whether the students have attained specified learning objectives. Only now, these activities all are occurring on the Internet.

Perhaps the epitome of transfer of the command-and-control instructional environment to distance education is evident in the "learning objects" movement. According to Wiley [1],

> This is the fundamental idea behind learning objects: instructional designers can build small…instructional components that can be reused a number of times in different learning contexts.…[They are] generally understood to be digital entities deliverable over the Internet. (p. 3)

Standardization is a goal of the learning objects movement [2] that is necessary to promote reusability, adaptability, and scalability (see Urdan & Weggen, [3]). Although learning objects could fall under the umbrellas of many instructional philosophies [4], they certainly are adapted to "teacher control" approaches to instruction. There are other ways, though, that seem to fit processes learners, especially adult learners, employ already quite naturally. This approach is summarized under the term *constructivism*.

Constructivism is a contrarian view of learning compared with the command-and-control approach. Constructivism has been defined as:

> A philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own "rules" and "mental models," which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences. [5].

Constructivism focuses on the building of learning by the learner. The belief is that learning is something that people do, not what is done to them.

Constructivist learning relies on self-organization of learning environments, aims, processes, and outcomes. Interestingly, it turns out that self-organization characterizes many processes in science and the natural world. In fact, the study of self-organizing systems provides not only theory and practice for describing many natural phenomena, but also self-organizing systems principles provide considerable insight into the design of

eLearning environments that capitalize on the power of the modern electronic network defining the Internet to mediate learning.

In the remainder of this paper, after providing an overview of the general systems approach, self-organizing systems theory and practice are reviewed briefly, especially with applicability to learning mediated by networks. Then, an analysis is presented of the self-organizing learning properties of *PerlMonks* (see http://perlmonks.org), a very popular and influential online social learning system. These properties suggest a new wave of highly individualized learning systems that could capitalize on the ever-growing reach and span of the global Internet in ways that promote constructivist learning environments.

The Ubiquity of Systems

A system is a group of independent, yet interrelated, elements that follow a pattern and fulfill a purpose. Following the philosopher Hegel's dictum, "The truth is the whole," a system is indivisible, and its elements are inseparable. For instance, a tree is a unified whole. Separate the leaves from a deciduous tree and you have something that is not, well, a deciduous tree. And, the leaves of a deciduous tree do not function separately from the tree itself. A leaf is not viable without its connection to a tree.

The system that defines a tree actually is a complex of subsystems that function together and form their own connections to other, external systems. For example, a tree contains anatomical and physiological subsystems that interact with each other within the suprasystem of the tree. The inputs and outputs of photosynthesis systems embedded within the tree system are connected with other living systems that produce carbon dioxide as a byproduct and require oxygen as an input. Certainly, understanding the nature and function of a complex entity such as a tree requires a systems perspective. In general, viewing the world from a systems perspective reveals the highly organic nature of existence, the surprising interdependence of seemingly unrelated phenomena, and, indeed, the very soup that mixes, organizes, and causes us and our temporal world to evolve.

Analysis of systems and the interactions among their elements certainly could yield enormous insights into the nature and workings of our complex physical world. A systems view of human activity also can pay similar dividends. As John Donne, an English poet and essayist whose life spanned the late 16th and early 17th centuries, wrote in his *Meditations XVII*, "No man is an island, entire of itself; every man is a piece of the continent, a part of the main." Everything humans are or do is connected—directly or indirectly, proximally or distally, chiefly or tangentially—to everything else. A systematic perspective of phenomena facilitates our grand human task of apprehending both the intention and the context of human action, which sociologist Max Weber once described as *verstehen*.

Nature of Emergent, Self-Organizing Systems

A system is composed and defined by its parts. However, many systems really are *more than* the sum of their parts. Systems function, at times, in ways that cannot be attributed to any of the individual parts of the system separately. Such systems are termed *emergent systems* because they feature the appearance of a property not previously observed as a functional characteristic of the system. In fact, the emergent system has properties that arise out of its organization and that cannot be reduced to the properties of its individual elements. For instance, an airplane is an emergent property of its interconnected parts. That emergent property disappears if the parts are disassembled and just placed in a heap. As with the airplane, higher order system properties emerge from lower order embedded systems.

Systems emerge into an organized form in the absence of external stimuli or constraints. That is, systems can self-organize as a result of dynamic mechanisms through which new structures and capabilities appear at the global level of a system from interactions among its lower-level constituents. A classic example of emergent, self-organization is provided by Garfinkle [6], who described the interesting life cycle of the cellular slime mold, *Dictyostelium discoideum*.

The slime mold spends one phase of its life as individual amoebae, which are single-celled animals that locomote, feed on bacteria, and otherwise exist as self-sustaining organisms. Deprived of food, however, the amoebae aggregate into colonies of thousands of cells. These colonies, which emerge from millions of single amoebae, fuse and act as one entity to migrate over macroscopic distances in search of food.

In search of food, the integrated organism formed by the slime mold colony differentiates. Part of the millions of amoebae in the colony becomes a foot or base rich in cellulose. Another part of the colony of slime mold amoebae differentiates to become a fruiting body rich in polysaccharides. The fruiting part of the colony later bursts, releasing individual amoebae and completing the life cycle. This foot or base can move the entire slime mold chemotactically, that is, in response to a chemical attractant secreted by the individual amoebae. In this way, the colony "walks." Remarkably, some research shows that the entire colony, composed of millions and millions of individual amoebae acting in common, can learn to work its way through a maze to reach a food source.

How do slime mold amoebae aggregate and act in consort in much more sophisticated ways than might appear evident from consideration of the limited potential of any individual amoebae? Understanding this phenomenon is the mystery and promise of emergent, self-organizing systems. An assertion in this paper is that the same principles of emergence and self-organization that influence the collective behavior *Dictyostelium discoideum* and many other phenomena (from, to mention a few examples, the evolution, order, and behavior of galaxies to the pathways carved by rivers to the

functioning of neural networks to the sophisticated collective behavior of such social insects as ants, wasps, or fireflies with decidedly limited individual behavioral repertoires) can apply to the creation and diffusion of knowledge among people engaging in social learning through networks.

Processes of Self-Organization

The scientific study of emergent, self-organizing systems is relatively new. The science of these systems has grown out of many disparate scientific fields, including physics, chemistry, biology, cybernetics, computer modeling, and economics. Many natural systems show organization (e.g. galaxies, planets, chemical compounds, cells, organisms, and animal societies). Traditional scientific fields attempt to explain this tendency to self-organize by referencing the micro properties or laws applicable to their component parts (e.g., gravitation or chemical bonding). Self-organizing systems theory approaches the subject in quite a different way, looking instead for system properties that are applicable regardless of size or nature.

The essence of self-organization is that system structure often appears without explicit pressure or involvement from outside the system. Any system that takes a form that is not imposed from outside (by walls, machines or forces) can be said to self-organize. The term, self-organization, usually is employed, however, in a more restricted sense by excluding physical laws as reductionist explanations of the emergence of organization.

Heylighen [7] subjected a variety of diverse areas of study to analysis through principles of self-organization, including magnetism, crystallization, laser action, Belouzov-Zhabotinsky/Brusselator reactions (ordered patterns in a solution), cellular autocatalysis, morphology of organisms, bird and fish flocking, immune system operation, neural networking, ecosystem operation, and functioning of market economies. Self-organizing principals are evident in each of these diverse phenomena. Each instance can be shown to arise without resort to explanation from physical laws or from metaphysical first principals.

How does self-organization occur? As Ashby [8] noted in an early paper in the literature on self-organizing systems, dynamic systems, independent of their type or composition, always tend to move to a state of equilibrium. In the lexicon of current discussions of self-organizing systems theory, this state of equilibrium is called an *attractor*. This movement toward an attractor reduces uncertainty about the system's state, and therefore the system's statistical entropy (a measure of uncertainty about a system's state). This movement is equivalent to self-organization.

von Foerster [9] formulated the principle of "order from noise," which stated that the larger the random perturbations ("noise") that affect a system, the more quickly it will self-organize ("order"). Nicolis and Prigogine [10] offered a related principle of "order through fluctuations." Many systems are non-linear, that is, their effects are not proportional to their causes. Non-linear systems often hold several attractors. When a system resides between attractors, chance variation, called "fluctuation" in thermodynamics, pushes the system either into one or the other of the attractors. Systems organize themselves around attractors. Noisy systems continue to bifurcate among attractors until they reach an equilibrium state. In fact, new, different properties of systems emerge through abrupt changes similar to phase transitions such as those using heat to move H_2O from solid (ice) to liquid (water) to gaseous (steam) states.

Self-organizing systems models have been applied to human communities for decades, at least since Jacobs' [11] groundbreaking work on urban planning. Jacobs argues that communities self-organize in a manner similar to social insects: instead of thousands of ants crossing each other's pheromone trails and changing their behavior accordingly, thousands of humans pass each other on the sidewalk and change their behavior. In the days before central planning authorities zoned city areas for specific uses, the simple local interactions of people on sidewalks led to complex global behavior at the level of the city, with upscale neighborhoods, slums, commercial and red light districts all emerging without anyone planning them. Ever play the game, *SimCity*?

Popular treatments of the field of emergent, self-organizing systems are offered by Barabasi [12], Goodman [13], Holland [14], Johnson [15], Kaufman [16], Krugman [17], Morowitz [18], and Ward [19]. The subtitles of Ward's [19] volume, *The Underlying Theory Behind, Life, The Universe, And Everything*, and Barabasi's [12] book, *How Everything Is Connected To Everything Else And What It Means For Business, Science, And Everyday Life*, reflect the meta-analytic tone characterizing most of the writing about emergent, self-organizing systems. Theory about self-organizing systems is beginning to penetrate discussion of the interaction of technology, knowledge management, and learning. For example, Eriksson and Wulf [20] explored the relationships between self-organizing systems and the notion of computer-supported collaborative work. And, Wulf [21] examined the ways in which "groupware" systems support self-organization. However, Wiley and Edwards [22] have provided probably the most coherent, integrative, and stimulating discussion of the potential role of on-line social systems in promoting learning under the umbrella of theory of emergent, self-organizing systems.

An Application of Self-Organization to Self-Directed Learning Systems: perlmonks.org

Practical Extraction and Report Language, Perl, is a programming language that is commonly used for writing CGI scripts used by most servers to process data received from client browsers (http://www.oit.ohio-state.edu/glossary/gloss3.html). Perl, a robust programming language frequently used for creating CGI scripts on Web servers because it is faster than UNIX

shell script programs, can read and write binary files, and can process very large files (http://www.wmo.ch/web/www/WDM/Guides/Internet-glossary.html). It has become the language of choice for World Wide Web development, text processing, Internet services, mail filtering, graphical programming, systems administration, and every other task requiring portable and easily-developed solutions (http://manual.liquidweb.com/chapter3/glossary.html). Perl has a large community of contributing programmers and, moreover, costs nothing and is free to redistribute because it is open source (http://datacenter.5points.net/datacenter/support/glossary/)

PerlMonks is a web site (http://perlmonks.org) that is an excellent example of application of principles of self-organization to social learning mediated on networks. The *PerlMonks* web site is "an attempt to make learning Perl as non-intimidating and easy to use as possible, a place for individuals to polish, improve, and showcase their Perl skills, and a community which allows everyone to grow and learn from one another" (http://perlmonks.org/index.pl?node_id=243870). One of the lead "monks" at the *PerlMonks* site, identified only as "nate," writes that:

> We were aiming for a cool Internet hangout for Perl gurus and semi-advanced users. We wanted to offer an environment where people could ask questions, post their best work, and just basically geek out on Perl. My first official title in the company [at which I work] was "Perl Monk." I guess I liked the philosophy behind being a monk. There's a religious connotation, and Perl is a language that some people take as seriously as a religion. Monasteries are culturally known as centers of learning and knowledge, and that is a good analogy of what we're trying to build. Eventually, all these questions people are asking will make a tremendous archive of question-and-answer style documentation, and we'll be working on ways to make this more accessible to people.
> (http://webdevelopment.developersnetwork.com/Articles.asp?Article=100).

PerlMonks is community–driven and run by volunteers. More specifically, "Orders of Monks are responsible for the day-to-day upkeep, such as editing nodes, writing documentation, and fixing bugs" (http://perlmonks.org/index.pl?node_id=243871). These Orders of Monks actually are self-organized groups of people who work to maintain and care for the *PerlMonks* site. "Belonging to any of these groups does not give these people XP, nor do they get free coffee from Starbucks" (http://perlmonks.org/index.pl?node_id=238736). Participating in *PerlMonks* is a labor of love—or, maybe that should be a labor of enlightenment made full by hauling around the three baskets of wisdom about Perl. I wonder if it means you have to be a vegetarian?

On *PerlMonks*, users called "gods" establish and control policy for the *PerlMonks* community site, and they direct most of the site's development. Doing most of the difficult development work are "pmdev," or PerlMonk developers. "Power users" mainly enforce etiquette by shutting out users who are considered annoying. In PerlMonk culture, to be shut out is to be "borged," and a user who is borged is said to be in the "belly of the borge."

"Janitors" fix up ugly site code, delete duplicate content, and generally clean up around the site. However, they do not edit content. Submissions are treated as holy (and wholly, I guess) unto themselves. "Site Doc Managers" form a clan of people who write the FAQs for the *PerlMonks* site. There even is a "Cabal" set up to allow various participants to read each other's Wikis (a Wiki is a web page that is editable by a group). And, what would a monastery be without an offering plate? The Perl Foundation accepts tax deductible donations for site operation via checks, credit card payments, and PayPal donations.

PerlMonks provides an opportunity for learning community participation. The "Monastery Gates" form the home page of the *PerlMonks* site (see http://perlmonks.org/index.pl?node_id=131). Through the Monastery Gates, the user views the centerpiece of the *PerlMonks* experience—the "Seekers of Perl Wisdom" area (see http://perlmonks.org/index.pl?node=Seekers%20of%20Perl%20Wisdom). "Seekers of Perl Wisdom is the main section for asking questions of the Monks" (http://perlmonks.org/index.pl?node_id=17974). For instance, *snaparoz*, the nickname of a novice participant in PerlMonk, wrote on 28 April 2004 at 12:40:

> Hello, Monks, this is my first posting here. I need help with something basic, but I couldn't figure it out myself, and browsed through several sites, beside this, before posting. So: I need to convert files from ASCII into Unicode UTF8. I work on WindowsXP, use ActiveState Perl 5.8 . I tried this (and many other variants...):
>
> ```
> use Encode;
> $infile=shift;
> $outfile=shift;
> open IN, $infile or die;
> open OUT, ">:utf8", "$outfile" or die;
> while(<IN>) { print OUT $_; }
> ```
>
> It does not work. It actually screws up upper ASCII characters that are OK when NOT using the utf8 part in opening the output file. Any idea about what I am missing here?

Through an "Offer to Reply" button, *snaparoz* received three very specific replies within three hours of the original posting, which, in turn, generated a thread of another three replies that corrected, extended, and, otherwise, perfected the answer provided to *snaparoz*. Problem solved collaboratively.

PerlMonks participants decide the content of *PerlMonks* postings. No one provides prior organization of the topics discussed, although some weeding out of off-topic questions occurs. There is no lesson plan for participants in *PerlMonks*. In fact, *PerlMonks* does not

explicitly market itself as a learning community. Rather, topics for discussion percolate from the daily questions, thoughts, problems, and practices of the *PerlMonks* community. In this way, questions, the answers, and the learning that ensues self-organize. The quality of discussion on *PerlMonks* is regulated by users, who immediately challenge flaky ideas, enrich discussion, or correct facts.

Seen from the perspective of learning system design, *PerlMonks* encompasses some useful constructivist conditions for learning. A few conditions evident within *PerlMonks* (many more are embedded) include: (a) authenticity, (b) real-time quality, (c) distributed knowledge creation, (d) social construction of knowledge, and (e) induction into a learning community through staged participation.

Authenticity in promotion of new knowledge

Adults require a strong link between the content of their learning and the content of their lives. Authenticity is critical to their learning. Self-organized *PerlMonks* themes have the virtue of emerging from the problems, issues, and opportunities confronting members of the *PerlMonks* community. The result is "just-in-time" learning drawn from the lives of community members. Because the content of *PerlMonks* is drawn from life, *PerlMonks* does not deal with simple textbook problems and issues. Rather, *PerlMonks* content is complex and ill-structured (just like life), which requires participants to engage in higher-order thinking and in case–based, problem–based learning that is so essential for transfer of learning to new contexts (cf, Jonassen, [23] for a discussion of complexity and authenticity).

Quality of knowledge through real-time peer review

Opinions and facts running through themes of *PerlMonks* postings certainly are personal and often are delivered with passion and conviction. However, do these postings contain useful knowledge? A virtue of *PerlMonks*' community processes is that postings containing specious reasoning, faulty facts, unproven assertions, and anomalous findings receive quick community reaction. The subscriber base of *PerlMonks* contains broad and deep expertise and curiosity. Peer review of ideas offered in *PerlMonks* postings occurs almost in real time. Compare this to the slow, creaky review and publication cycle for "new knowledge" in traditional refereed journals.

Rejection of the "tyranny" of the expert in knowledge creation

In traditional learning systems, an instructor or a few subject matter experts decide what is taught, how it is taught, and what criteria are employed to certify that learners have mastered the content set forth. In *PerlMonks* there is no central control. As a consequence, something similar to Adam Smith's "invisible hand" performs these functions using the entire *PerlMonks* community. Also, because expertise is distributed and varied, not central and uniform, the multitude of *PerlMonks* participants are more intelligent than one or two content experts ever could be. And, by the way, this feature of *PerlMonks* is a solution to the problem of "low teacher bandwidth" (the inability of most online learning systems to actually scale to many learners) described by Wiley and Edwards [22] that is imposing economic and structural limitations on the adoption of online learning systems.

Social interaction to create new knowledge

A distinction often is made between "knowing that" and "knowing how" (see Polanyi, [24]). For instance, one may learn the nomenclature and taxonomy of the human skeletal system in osteology ("knowing that"). Drill–and–practice, memorization, mnemonics, and other personal techniques for learning facts are useful. However, learning to conduct surgery on human bones ("knowing how") is best accomplished by adult learners through actual practice and through social interaction with other learners, through observation of practice, and through brief apprenticeships in teaching and learning. Social interaction is essential in "knowing how" to perform because "learning how" is a social–dialogical process of negotiating tacit knowledge, through dialogues and conversation (cf, Duffy & Cunningham, [25]). The wide variance often found in practice, the nuance found in exemplary performance, and the translation required between theory and practice are best mediated through social interaction. *PerlMonks* provides a base for computer-mediated social interaction.

Legitimate peripheral participation to induct new entrants

Not every *PerlMonks* subscriber or reader takes an active role in posting and responding to *PerlMonks* questions and answers. Lave and Wenger [26] in their seminal work, *Situated learning: Legitimate peripheral participation*, noted that new entrants to learning communities undergo a period of induction. During this period, new entrants become acculturate by acquiring the *PerlMonks* community's norms, beliefs, language, and modes of operation. In a way of speaking, new entrants to a community are apprentices. Interestingly, the notions of master and apprentice are entirely situational. Depending on the topic, a new entrant could be a master, and a more mature participant even might be an apprentice. In a large, distributed community such as *PerlMonks*, a specific master–apprentice relationship usually is not practical. Instead, newcomers to *PerlMonks* have a very loose coupling to other participants. This loose coupling allows the newcomer to view *PerlMonks* operations from a sort of observational outpost from which they learn to "do" *PerlMonks* as they benefit from cognitive engagement in the news postings and the sometimes heated discourse around the postings. In this way, the *PerlMonks* experience becomes something that participants live rather than receive and becomes a source of identity and motivation.

Conclusion

PerlMonks is an example of a emergent, self-organizing system that promotes learning without overt management in a large, distributed community mediated by the global Internet. In what is essentially a self-directed learning effort, *PerlMonks* participants organize their own learning around authentic, real-world problems which they choose. Community regulatory mechanisms control the quality of the information offered in response to questions submitted to *PerlMonks*. *PerlMonks* makes use of the global Internet to provide social interaction over a distance to allow new and revised ideas to emerge through processes of social discourse and negotiation. Also, *PerlMonks* allows participation at apprentice and master levels, but the distinction between masters and apprentices remains quite fluid, mirroring the highly distributed and situational nature of expertise.

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