Common Wisdom: Peer Production of Educational Materials, Center for Open and Sustainable Learning

Common Wisdom: Peer Production of Educational Materials

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A few years ago I took my kids to South Street Seaport, to see a Viking ship replica that had anchored there, after crossing the North Atlantic in a reenactment of Leif Ericson's voyage. When we got home the boys were curious, so we googled "Viking Ships" and found a fascinating mixture of sources and pictures. The first site was a Canadian site, which included a collection of resources, essays, and worksheets. An enterprising elementary school teacher, Jim Cornish, at the Gander Academy, an elementary school in Newfoundland, seems to have put these together. He has essays on different questions, and links to sites hosted by a wide range of individuals and organizations, such as a Swedish museum, individual sites hosted on geocities, or a picture of a replica Viking ship hosted on a commercial site dedicated to selling nautical replicas. This multiplicity of sources of information that show up on the very first site was then replicated as one continued to explore the remaining links. The second link was to a Norwegian site called "the Viking Network," a web ring dedicated to preparing and hosting short essays on Vikings. It included brief essays, maps, and external links, such as one to an article in Scientific American. "To become a member you must produce an Information Sheet on the Vikings in your local area and send it in electronic format to Viking Network. Your info-sheet will then be included in the Viking Network web." The third site was maintained by a Danish commercial photographer, and hosted in Copenhagen, in a portion dedicated to photographs of archeological finds and replicas of Danish Viking ships. A retired professor from the University of Pittsburgh ran the fourth. The fifth was somewhere between a hobby and a showcase for the services of an individual, independent web-publisher offering publishing-related services. The sixth and seventh were museums, in Norway and Virginia, respectively. The eighth belonged to a hobbyists' group dedicated to building Viking Ship replicas. The ninth was to classroom materials and teaching guides made freely available on the Internet by PBS, the American public broadcasting network.

The Internet today connects close to a billion people around the planet. These individuals have access to, at least, a computer and a network connection. They have access to software that allows them to author text and combine images. Many of them also have digital cameras, sound recording capabilities, and, through access to the web, a wealth of software available at no or low cost—some of it free or open source, other proprietary, but with a distribution model that allows individual, non-commercial users to use the software without paying a price. The fact that this vast pool of human talent, interest, knowledge, and experience now has, as it never had before, access to the basic necessary physical capital necessary to make and communicate cultural materials of all sorts has created a deep transformation in the digitally networked environment, and in the information economy and society. The critical change is that social production based on commons, rather than property, has become a significant force in the economy.

The most widely known example is free and open source software: thousands of volunteers have been producing some of the world's most significant software, in collaborations both large-scale and small, with a degree of efficacy that commercial producers are finding difficult, and sometimes impossible, to compete with. The first response of economists, businesses, and regulators to the emergence of free software was "it isn't really happening." That is, it's a fluke. The second response was: "there's something special about software." Either its characteristics as a production good were so quirky as to make it a unique event, or the universe of software developers was a queer tribe characterized by an oddly cooperative culture. But the earth continued to move, and more information, knowledge, and cultural goods came to be developed through the social production system made newly powerful by the network. In particular, we saw large-scale projects developing, without relying on markets or clear hierarchies, but rather based on social signals and motivations to organize significant productive enterprises. I called these phenomena *commons-based peer production.* The Open Directory Project, a collaboration of sixty-thousand volunteers, came to replace Yahoo as the human-edited directory of record. It turned out that even a very successful company like Yahoo, with hundreds of paid employees looking at websites and updating a directory, could not compete with tens of thousands of volunteers, each of whom cares deeply enough about a subject or two to spend a couple of hours a week poking around and continuously improving the listings in his or her favorite bailiwick. Businesses like Google learned to integrate the judgments of widely dispersed individuals into their core business. PageRank, Google's relevance algorithm, effectively produces an image of the distributed judgments of millions of webpage authors around the Web, expressed through their decision to link to some websites and not to others, and has on this practice built the most successful search engine of the Web. Slashdot, a site that allows a quarter of a million users to share the news they stumble across in technology and comment on it, has become a leading technology newsletter site. And the list continues into most nooks and crannies of most areas of the Web. But not all. There are still, for example, no good collaborative alternatives to novels. What I want to do in this paper is to look at textbooks and other educational resources, and think of whether, at baseline, they are amenable to peer production, what may be the limits of this amenability and the barriers to peer development of educational materials, and what strategies or breakthrough innovations might facilitate wider development of educational resources in a commons-based and peer production model.

There are two significant reasons to be interested, as a matter of normative concern, with the trajectory and viability of peer production of educational materials. The first is primarily concerned with quality of education everywhere. The second is more narrowly, but no less importantly, concerned with access to educational materials in poorer countries. The problem of quality is best exemplified by the K-12 textbook market.[i] Significant consolidation in the past decade has left four major textbook publishers in the United States. At the same time, statewide adoption practices have meant that decisions by government officials in California, Texas, and Florida control the demand in roughly a quarter of the K-12 textbook markets. The combination has led to the content of most textbooks being determined through intense lobbying in the three state capitals. Because of the benefits of economies of scale in not producing different texts for these states, and then for others, textbooks have become relatively homogenized and aimed at some lowest common denominator—which may be challenging for states with cultures as different as those of Texas and California. The question then becomes, to what extent is it possible to use commons-based production of educational resources, and in particular peer production that pools the resources of teachers and interested members of the public more generally, to produce a much more varied and high-quality set of materials out of which teachers and schools could weave their own tapestries for their students.

The second, no less important motivation for looking at peer production of educational resources has to do with the systematic failure of market-based strategies to solve problems of access to knowledge among the world's poor. Barriers to the production, development, and distribution of textbooks and teaching materials in poor countries are high. They are neither the sole barrier to education, nor are they even the sole barrier to access to textbooks.[ii] Problems such as availability of paper to print, and distribution systems of physical objects may overwhelm any effort to produce textbooks or other educational resources in languages and frames within, and appropriate for, poor countries. Nonetheless, if it is indeed possible for at least the content of materials, or their digital instantiations, to be produced in a way that harnesses a global creative force and does not impose a price on its outputs, then it may be possible to eliminate at least one set of barriers to access to education even in poorer economies.

Information, knowledge, and culture are "public goods" in the strict economic sense. That is, information is a nonrival good. Once information is created, the marginal cost of its use is zero. Tolstoy need not spend a second more on *War and Peace* in order to satisfy the one hundred millionth reader than he did to provide the book to its first reader. From a technical economic perspective, this means that information, once produced, should be available at its marginal cost—zero—if it is to be utilized efficiently. Regulatory systems like copyright or patent, that allow private parties to exclude others from using information unless they pay a price that is above zero, are therefore justified in terms of their dynamic effects. That is, while it is inefficient to have existing information goods priced at a positive price, it is nonetheless efficient to have these kinds of exclusion rights so that market-based producers will engage in the useful activity of creating new information, knowledge, and culture. Even dynamically, however, this argument is only partially correct, because information is both input and output of its own production process. This is known as the "on the shoulders of giants" effect. To the extent that information is a public good, the efficient price for information as input is also zero. Pricing information at above this price retards new creation, as well as "consumption," to less-than-efficient levels. The tradeoff therefore is between how much, at any given level of regulation-created exclusivity, new incentives to produce are created from the ability to charge higher prices on more uses of the information, relative to how much the cost of creating information is increased because of the expanded exclusivity. This is the basic economic tradeoff involved in designing systems of exclusivity, like copyrights and patents.

The reason for this brief primer on the economics of information is that it explains quite easily why we have continued to observe, throughout the industrial revolution and the rise of market economies, a large and stable component of information production that has been based on strategies that do not depend on proprietary exclusion from their outputs. We do not have large nonprofits dedicated to the production of cars or steel. But universities have not only survived, but grown and thrived as centers of research, writing, and education. We do not have amateurs coming together to make furniture or build buildings (Amish barn raisings notwithstanding), and yet amateur choirs, reading groups, news-focused conversations and similar social activities have been central to how we create and exchange information and culture. Non-market action based on taking information that is available in the public domain, not subject to exclusivity, mixing it with new creativity, wisdom, and time, and making new moves in the conversation that is our knowledge production system has been, and continues to be a central part of how that system functions. This is, broadly speaking, "commons-based" production—production that uses inputs from a commons over which no one has exclusive rights, and that releases its outputs back into the commons, to enrich both its creators and anyone else who, like them, follows the same patterns of production.

Peer production is a narrower subset of commons-based production. The critical defining characteristic is that, in addition to being commons-based the activity involves at least concordant coordinated action of larger numbers of individuals, and, more often, actual cooperation among participants in a project or enterprise. The coordination or cooperation is then not achieved, as in markets, through price signaling based on property rights and contracts. Motivation too, is not achieved primarily through material rewards measurable in crisp amounts—like salaries or bonuses. Neither are coordination, cooperation, or motivation achieved as they are in firms or bureaucracies, through a system of command and control, the sending of orders and the monitoring and rewarding or punishing of compliance. Instead, peer production enterprises rely on a set of social signals and social-psychological motivations to both motivate and direct or organize the disparate productive efforts of the many contributors. For example, the free software movement includes both commons-based and peer production efforts. Some free software development projects include only one or a small number of developers. They release their code under the common license used by most projects of this sort—the GNU GPL (General Public License), thereby releasing their outputs into a self-binding commons. But they are not a large-scale enterprise coordinated through social signals and motivations. On the other hand, some of the most visible projects, like the Linux kernel development project or Apache web server, are peer production enterprises, comprising thousands of volunteers organized through a combination of licensing provisions, social norms, and communications platforms like message boards.

The distinction is important because it pertains to what sort of behavior is likely to be necessary for what outcome. For many digital learning objects, a well-searchable space in which individuals simply make objects and make them available freely is enough to generate a wealth of components that teachers can then mix and match to create their own collection. In this regard, a commons-based effort like the Web at large is likely to be the best source, ultimately, of digital learning objects. If peer production is necessary, it is likely to be focused on the filtering and accreditation of the universe of objects that will be created and accrete in the network as a whole. Deciding which of these objects is of high quality, or mapping which objects will be good for which educational activities, are likely to be the kinds of activities that will necessitate peer production—the collective efforts of a large group of users who will look, try, and report on the quality of various objects. On the other hand, more comprehensive educational materials, like sophisticated immersive games or textbooks, are likely to require large scale efforts, and therefore large scale cooperation, if they are going to be produced outside of the market, proprietary system. It is here, then, that it begins to be important to understand the anatomy of peer production, how these projects are organized, and what are the characteristic pitfalls and solutions.

Discrete Learning Objects and Commons-based Production

Consider what is perhaps the simplest of educational resources: a discreet learning object. Let us define it for this purpose in very broad terms; a discrete information object that focuses a learning experience for a student. While simpler than what is used in the literature,[iii] the distinctions should not affect the underlying economics or feasibility. It can be as simple as an image of a Viking Ship replica, or it can be a more complex interactive object, like a game that reinforces skills or allows a student to gain insight into a process. The discreteness of learning objects of this sort, as compared to a more sophisticated, integrated set of materials like a textbook, is that they can be created whole in small and discrete chunks, that need no conceptual coherence with other similar objects until the moment at which they are collated into a learning experience—if that. Indeed, this modularity or "chunkiness" is often used as part of the very definition of learning objects. To understand why it is that we would likely expect such learning objects to abound in the digital environment and whether there is in fact a challenge to widespread adoption of their development and use leads us to explore some basic questions of motivation, quality, and why we see social production emerging to much greater importance in the context of the networked environment.

The first and critical enabling fact is cost reduction. Imagine the grade school teacher who wishes to put together ten to twenty pages of materials on Viking ships for school children. Pre-Internet, he would need to go to one or more libraries and museums, find books with pictures, maps, and text, or take his own photographs (assuming he was permitted by the museums) and write his own texts, combining this research. He would then need to select portions, clear the copyrights to reprint them, and find a printing house that would set his text and pictures in a press, pay to print a number of copies, and then distribute them to all children who wanted them. While the first steps are non-trivial, and have clearly been made cheaper by the Internet, it is the last steps—printing and distributing, that have truly changed in a fundamental way. Clearly, research today is simpler and cheaper. Cutting and pasting pictures and texts that are digital is cheaper. Depending on where the teacher is, it is possible that these initial steps would have been insurmountable, particularly for a teacher in a poorly-endowed community without easy access to books on the subject, where research would have required substantial travel. But even once these barriers are surmounted, in the pre-computer, pre-Internet days, turning out a product that looks and feels like a high quality product, with high resolution pictures and maps and legible print required access to capital-intensive facilities. The cost of creating even one copy of such a product would likely dissuade the teacher from producing the booklet. At most, he might produce a mimeographed bibliography, perhaps some text reproduced on a photocopier. But now place the teacher with a computer and a high-speed Internet connection, at home or in the school library or staff room. The cost of production and distribution of the products of his effort are trivial. A website can be maintained for a few dollars a month. The computer itself is widely accessible throughout the developed world. It becomes trivial for a teacher to produce the "booklet"—with more information, available to anyone in the world, anywhere, at any time, as long as he is willing to spend some of his free time putting together the booklet rather than watching television or reading a book.

When you multiply these very simple stylized facts by the roughly billion people who live in societies sufficiently wealthy to allow cheap ubiquitous Internet access, the breadth and depth of the transformation we are undergoing begins to become clear. A billion people in advanced economies have between two and six billion spare hours among them, *every day*. In order to harness two to six billion hours, the entire workforce of almost 340,000 workers employed by the entire motion picture and recording industries in the United States put together, assuming each worker worked forty hour weeks without taking a single vacation, for between three and eight and a half *years*! Beyond the sheer potential quantitative capacity, however one wishes to discount it to account for different levels of talent, knowledge, and motivation, a billion volunteers have qualities that make them more, rather than less, likely to produce what others want to read, see, listen to, or experience. They have diverse interests—as diverse as human culture itself. Some care about Viking ships, others about the integrity of voting machines. Some care about obscure music bands, others share a passion for baking. It is this combination of a will to create and to communicate with others, and a shared cultural experience that makes it likely that each of us wants to talk about something that we believe others will also want to talk about, that makes the billion potential participants in today's online conversation, and the six billion in tomorrow's conversation, affirmatively better than the commercial industrial model. When the economics of industrial production require high up front costs and low marginal costs, the producers must focus on producing a few superstars and making sure that everyone tunes in to listen or watch them. This requires that they focus on averaging out what consumers are most likely to buy. As long as it is expensive to produce music or the evening news, there are indeed few competitors for top billing, and the star system can function—whether it produces Britney Spears, broadcast news, or nationally-used textbooks. But once every person on the planet, or even only every person living in a wealthy economy and ten or twenty percent of those living in poorer countries, can easily talk to their friends and compatriots, the competition becomes tougher. Many more "niche markets"—if markets, rather than conversations, are what they should be called—begin to play an ever increasing role in the total mix of our cultural production system. The economics of production in a digital environment should lead us to expect an increase in the relative salience of nonmarket production models in the overall mix of our information production system, and it is efficient for this to happen—more information will be produced, and much of it will be available for its users at its marginal cost.

This leads to the more general statement of the problem of motivation. Our standard economic models for productive human action tend to assume that motivation is more or less homogenous, capable of aggregation, and reflects a utility value capable of summing within a single individual, even if not for purposes of interpersonal utility comparisons. This simple model was useful for economic modeling, but is wrong. There is now significant literature on the diversity of human motivation, on the availability of different forms of social, psychological, and material gain, and on the fact that there can be "motivation crowding out:" that is, that adding money to an activity will not necessarily increase the activity.[iv] Intuitively, this is hardly news to anyone who has not been indoctrinated in economics. That is, sometimes we do things for money. Sometimes, however, we do not. Ranging from trivial acts like responding truthfully and with diligence to a stranger's request for directions on the street, to quite substantial efforts we go to in order to help friends and family, or pursue a fun hobby, or do what we believe we ought to do as well adjusted members of society. While it is not impossible to describe all these in terms of different dimensions of utility, this characterization eases modeling at the expense of losing texture. The loss is particularly acute when we are trying to identify the potential efficacy and sustainability of an emerging set of productive practices that are distinctly not rooted in the market and in material motivation, and, indeed, are often in direct competition with market-based system. So let us work here with intuitive experience. At different times of the day, week, month, year, and lifetime, we dedicate different amounts of our time, effort, and creativity to different behaviors and interactions. At some points, we will be goal oriented and seek to satisfy our material needs and desires. At others, we will focus on maintaining our social or psychological well being through interactions that cannot be captured by money, or, indeed, would be ruined by the introduction of money—like having dinner with friends. Or sex.

This factual assumption about human beings becomes important when mapped on to the fact of one billion people constantly connected to the network. The network is what pools, and makes effective, the collective force of the few hours or portions of life where making money is not the object for any given individual, and the pool then becomes an enormous source of effort, will, and creativity. Once the cost of participating in the production of something useful is lowered sufficiently, the question of motivation becomes trivial. Someone, somewhere, will have a few minutes or an hour to perform an act, if that act can be performed in a few minutes or in an hour in a way that creates a persistent and useful object. The main problem then becomes archiving, searching, and filtering for quality and relevance.

As a practical matter this observation suggests that learning objects can be produced in a coordinate fashion around the Web. The size of the pool of developers and the very discreteness of the objects suggest that there will be a steady flow and accretion of learning objects, and those among them that will be released under an open license of some form or another will be able to be improved by further incremental contributions over time. The long term threat of failure in the development of learning objects will therefore come not from lack of objects, but from a lack of search and integration functions to apply to a growing universe of discrete objects. Here, the experience of peer production of relevance and accreditation offers various models for solutions.

The first, and intellectually simplest to imagine given present assumptions, is that there is a business model that has been well tried in other sectors around integrating and providing a useful interface to commons-created materials. Google, for example, "outsources" its most critical information production function—the designation of relevance—to the cloud of users who maintain websites. Its PageRank algorithm polls websites around the web as to which site they link to, and then ranks search results based on who has received the largest number of links. Obviously the details of the algorithm are more sophisticated and complex. But the basic model is there. A company understands that valuable information exists because it is generated as a side effect of the human will to communicate, enabled by the web. It builds a tool to integrate the collected wisdom of these acts. The result is a superb search engine and a good business model to boot. Red Hat and IBM perform a parallel function with the GNU/Linux operating system. In the particular case of learning objects, a firm that is able to search, integrate, accredit, and package a set of tools for the creation of learning objects and a set of learning objects will have a valuable product. The trick will be, as it is whenever a market-based firm interacts with, or surfs on, the energy of a commons-based effort, to manage the cultural meaning at the interface of the market and non-market actors. Strict adherence to accreditation of source is likely to be indispensable. Providing the community of developers a platform that they can use free of charge or constraint to develop their materials, share them and expand them may be an important catalyst for action and approach to mediating the interface. Licensing can be important. Commitment, for example, to a creative commons type approach, and likely to two-tiered pricing where non-commercial individual use is permitted freely, but institutional and commercial use are not, is also likely to contribute to acceptance of such a firm as a collaborator, rather than a free rider and threat.

Completely commons-based solutions are also possible. One approach that we are beginning to see in the area of academic publication is the combination of self-archiving and standard tagging of materials. Academics in many disciplines are beginning to adopt the practice of archiving their working papers, and sometimes their published materials, on their own websites—whether managed alone or by their institution. Self-archiving of this sort is similar, functionally, to self-archiving of teaching objects by their creators. The critical point that self-archiving needs to respond to is visibility, or filtering. One approach to solving this problem is being developed at the University of Michigan, and is called OAIster (OAI stands for Open Archive Initiative). The project has developed a set of standard tags that each author can associate with his or her materials, making searching easier and more accurate. A different approach is the creation of open access self-accession archives, like ArXiv. ArXiv, what began as the Los Alamos Archive, is an archive of physics related papers (and later and to a lesser extent computer science and mathematics as well). Scholars post their working papers, receive comments, upload updates and changes, etc., before they publish in the formal peer review system, if at all. In the case of discrete learning objects, repositories and listings of repositories can serve that function.[v] As long as the set of developers are teachers, academics, or hobbyists that do not seek to exclude non-paying users, there is every reason to think that some repository of record will emerge as sufficiently widely used that both developers and users will begin to converge on it. This would, ultimately, create a globally-accessible repository of learning objects, and through this overcome the basic problem of finding objects.

Collecting objects or accessing them is the easier of the two tasks necessary to make widespread, coordinate but not purposely cooperative efforts around the web cohere into a universe of usable objects. The more difficult task is to create a system for filtering and accreditation that would separate the wheat from the chaff. The sheer magnitude of the universe of materials that are and will likely be produced in an open network, particularly as the cultural habits of creative engagement diffuse in the population, suggests that the problem of accreditation and filtration will be a very large one. And one of the things that we have learned from the experience of the networked environment is that an information creation project as large as this is best approached, again, through peer production.

In the mid-1990s firm-centric views competed as strategies for searching and indexing the newly growing Web. The first were search engines like Altavista or Lycos. The second was Yahoo. The theory behind the search engines was that smart software developers would write the best possible algorithm to extract human meaning and relevance from a mechanical analysis of text and metatags in webpages. Yahoo's innovation was to add human beings—its employees would look at websites, decide on their meaning and quality, and include and index them in a directory of the Web. In both cases the idea was that firms would pay smart employees to map the web, each in its own way. Both were largely wrong, and each in its own way lost to a competitor that used peer production instead. Google's search algorithm, we have already seen, is aimed at the best possible capture of the opinions of website authors about which sites are good and relevant, rather than aiming at having the software itself be good enough to make that judgment mechanically. As for Yahoo, its peer produced alternative was the Open Directory Project. While Yahoo continues to be a successful company, it has done so by moving in very different directions. Its staff of paid employees could not effectively compete with sixty thousand volunteers, each monitoring one or two areas of particular interest to them, including and excluding sites as they spent small increments of time reading and surfing things they might well have spent time on anyway, but adding their knowledge in small increments to a volunteer run and peopled directory. As the universe of creators of utterances—like discrete learning objects—approaches the size of the online population, what we begin to see is that mechanisms develop to pool the universe of creators into also being the universe of peer reviewers and accreditation providers. This suggests that anyone seeking to create an aggregation platform—be it a business or a commons-based effort—will need to design the accreditation function into the aggregation platform, and to provide tools for the users of the materials as well as their creators to comment, rank, categorize, and modify the educational resources pooled in this form.

Some educational resources that necessarily require higher order coherence depend in large measure on the teachers—both in terms of their quality and their culture—and on the ambitions of the education system in which they operate. At one end of the spectrum lies that role of the teacher at an undergraduate or graduate school in the United States. In the ideal type of this stage of education, the instructor has more-or-less complete freedom, as far as university administration is concerned, to structure the syllabus, and by cultural practice is expected to pull together materials from various sources into what is a more-or-less unique educational experience—taking this course from that professor is expected to be different in meaningful ways form taking it from the other professor. If this ideal-type model were in fact descriptively true, and if it were true throughout the education system beginning with kindergarten, then a universe of well-searchable and well-tagged and accredited discrete learning objects would be more-or-less sufficient to support teachers. Each teacher would create his or her own curriculum, syllabus, and classroom framework; and students in student-centered learning environments could do the same. At the other end of the spectrum stand two very different types of opposite models. One is the oft-stated quip that the French education minister could look at his watch and know what every child in every classroom is studying. The other is the concern that teachers in K-12 education system are underpaid, unmotivated, often unqualified, and need simple digestable materials that hold them by the hand through a course. Neither of these two descriptions need be true, descriptively, to nonetheless outline the two critical concerns that limit the applicability of the fully distributed, chunky or modular environment populated by learning objects which are brought together for each teacher and each student in a unique moment of learning tailored to that educational relationship. The first concern is the quality of the teacher. The second concern is the degree to which the organizational system, and in particular the state in the context of K-12 education, is willing to give teachers the degree of freedom entailed by a fully distributed and modular system of educational resources.

Higher order materials replicate the characteristics of integration and accreditation platforms, but at the level of content. Let us begin, then, with a brief overview of the most ambitious and successful collectively authored text, which, nonetheless, is still only halfway to a real integrated higher-order text. Four years ago Wikipedia began as a small effort, with fewer than ten contributors and 25 articles. By mid 2005, it has grown to an effort encompassing over fifty-five thousand contributors, who have coauthored and update and maintain close to two million articles in about two hundred languages, ten of which involve over a thousand volunteers and over fifty thousand articles each. There are, as of this date, no formal analyses of the quality of Wikipedia, but repeated anecdotal accounts, as well as multiple informal efforts to survey various definitions suggest that, in terms of quality, Wikipedia is at least as good as or better than the major online encyclopedias currently available, with the possible exception of Britannica. Moreover, it clearly improves over time, with some, but surprisingly little, noise. Wikipedia is a good example for higher order materials, because unlike peer production of relevance, or large posting-based newsletters like Slashdot, it exists around and operates through single textual documents. A Wiki is a program that allows many people—in the case of Wikipedia, anyone, including unregistered users—to edit the main document online, through a simple web interface, and save their edits to what becomes the single canonical, updated version of the collectively-authored text. Wikipedia is, nonetheless, only a partial example, because it is an encyclopedia, not a whole text. Like learning objects, encyclopedia definitions are distinctly chunky or modular. They can progress at different paces, have different voices, but, as long as they are accurate and reasonably well written, they need not form any higher-level coherence. Now, as we shall see, a textbook may not in fact be as modular as an encyclopedia entry; certain themes, approaches, or theories need to run through the whole and therefore require yet higher order coordination. This creates one more layer of complexity in reaching a genuinely integrated higher order education resource. Before we go there, however, let us look a bit more closely at how Wikipedia works.

Wikipedia combines three core characteristics. First, it uses a collaborative authorship tool, a Wiki. This platform enables anyone, including anonymous passers by, to edit almost any page in the entire project. It stores all versions, makes changes easily visible, and enables anyone to revert a document to any prior version as well as to add changes, small and large. All contributions and changes are rendered transparent by the software and database. Second, it is a self-conscious effort at creating an encyclopedia—governed first and foremost by a collective informal undertaking to strive for a neutral point of view, within the limits of substantial self-awareness as to the difficulties of such an enterprise. An effort to represent sympathetically all views on a subject, rather than to achieve objectivity, is the core operative characteristic of this effort. Third, all the content generated by this collaboration is released under the GNU Free Documentation License, an adaptation of the GNU GPL to texts.

Perhaps the most interesting characteristic about Wikipedia is the self-conscious social-norms-based dedication to objective writing. Unlike some of the other large scale collaborative enterprises, like Slashdot, Wikipedia does not include elaborate software-controlled access and editing capabilities. It is generally open for anyone to edit the materials, delete another's change, debate the desirable contents, survey archives for prior changes, etc. It depends on self-conscious use of open discourse, usually aimed at consensus. While there is the possibility that a user will call for a vote of the participants on any given definition, such calls can, and usually are, ignored by the community unless a sufficiently large number of users have decided that debate has been exhausted. While the system operators and the founder of Wikipedia—Jimmy Wales—have the practical power to block users who are systematically disruptive, this power seems to be used rarely. The project relies instead on social norms to secure the dedication of project participants to objective writing. So, while not entirely anarchic, the project is nonetheless substantially social, human, and intensively discourse- and trust-based. The following fragments from an early version of the self-described essential characteristics and basic policies of Wikipedia are illustrative:

> First and foremost, the Wikipedia project is self-consciously an encyclopedia—rather than a dictionary, discussion forum, web portal, etc.
>
> Wikipedia's participants commonly follow, and enforce, a few basic policies that seem essential to keeping the project running smoothly and productively.
>
> First, because we have a huge variety of participants of all ideologies, and from around the world, Wikipedia is committed to making its articles as unbiased as possible. The aim is not to write articles from a single objective point of view—this is a common misunderstanding of the policy—but rather, to fairly and sympathetically present all views on an issue. See "neutral point of view" page for further explanation.[vi]

The point to see from this quote is that the participants of Wikipedia are plainly people who like to write. Some of them participate in other collaborative authorship projects. But when they enter the common project of "Wikipedia," they undertake to participate in a particular way—a way that the group as a group has adopted to make its product be an encyclopedia. On their interpretation, that means conveying in brief terms the state of the art on the item, including divergent opinions about it, but not the author's opinion. Whether that is an attainable goal is a subject of interpretive theory, and is a question as applicable to a professional encyclopedia as it is to Wikipedia. As the project has grown, it has developed more elaborate spaces for discussing governance and for conflict resolution. It has developed structures for mediation, and if that fails, arbitration, of disputes about particular articles.

The important point is that Wikipedia requires not only mechanical cooperation among people, but a commitment to a particular style of writing and describing concepts that is far from intuitive or natural to people. It requires self-discipline. It enforces the behavior it requires primarily through appeal to the common enterprise that the participants are engaged in, coupled with a thoroughly transparent platform that faithfully records and renders all individual interventions in the common project and facilitates discourse among participants about how their contributions do, or do not, contribute to this common enterprise. This combination of an explicit statement of common purpose, transparency, and the ability of participants to identify each other's actions and counteract them—that is, edit out "bad" or "faithless" definitions—seem to have succeeded in keeping this community from devolving into inefficacy or worse. A case study by IBM showed, for example, that while there were many instances of vandalism on Wikipedia, including deletion of entire versions of articles on controversial topics like "abortion," the ability of users to see what was done and to fix it with a single click by reverting to a past version meant that acts of vandalism were corrected within minutes. Indeed, corrections were so rapid that vandalism acts and their corrections did not even appear on a mechanically-generated image of the abortion definition as it changed over time.[vii] What is perhaps surprising is that this success occurs not in a tightly knit community with many social relations to reinforce the sense of common purpose and the social norms embodying it, but in a large and geographically dispersed group of otherwise unrelated participants. It suggests that even in a group of this size, social norms coupled with a facility to allow any participant to edit out purposeful or mistaken deviations in contravention of the social norms, and a robust platform for largely unmediated conversation, keep the group on track.

At a human and design level, Wikipedia probably provides the closest analogy for what collaborative authorship of higher-order educational resources would look like. This is, of course, a speculation, not an empirically grounded claim. But as Wales points out, people who get their fun and sense of fulfillment from writing an encyclopedia are a special bunch. The same is likely to prove true of people who decide to spend their time and effort on authoring educational resources. They may be teachers, parents, academics, or hobbyists, but they are all likely to be unusually committed as a common project to producing materials that are useful to teachers and students. The range of motivations will be diverse—from self-expression to love of knowledge, from participating in a community of teachers to frustration with the outputs of the tightly controlled textbook markets and a wish to have better materials to work with. As for defections and disruptive behaviors, there are always likely to be either simply destructive adolescents or even ideologically motivated spoilers. This is unlikely to be more or less true than for the Wikipedia entries on

Abortion or George W. Bush. But what the experience of Wikipedia shows is that, if the community of authors is large enough and diverse enough, and if the interface makes it slightly harder to change the text than to revert it back to its pre-vandalism state, then an engaged community can usually defend itself very effectively.

Efforts to apply the Wikipedia approach to textbook authorship have not, however, largely been successful. Where they have to some extent been successful, it has not been through genuine collaboration. The most visible and largest of these efforts is one that is part of the Wikimedia Foundation itself, the organizational umbrella of Wikipedia and other Wiki-based projects. Statistics on Wikibooks are not as readily available as on Wikipedia itself, but by the summer of 2005, two and a half years after Wikibooks was launched, the project claimed on its front page close to 10,000 modules of textbooks. By comparison, Wikipedia had, two years after launch, over 200,000 articles, and over 4200 registered users, more than half of each of this number in the English Wikipedia. Considering that Wikibooks already had the fame of Wikipedia to build on, its growth curve is decidedly lower, to the point of raising a question as to whether it is too low to actually take off. At first glance the comparison of textbook modules to encyclopedia articles seems unfair. The latter are likely to include much smaller chinks, and so creating many more of them is easier. While likely true, what makes these units the appropriate units of comparison is precisely that each of them represents the basic unit of contribution that is sufficiently coherent to form a significant enough contribution to advance the project. In other words, the fact that the granularity of the modules of Wikibooks and those of Wikipedia are different is a relevant difference in terms of organizational implications and likely success. I will say more about this difference in a few paragraphs, but first, let us look at the successes of Wikibooks.

The site includes a list of Active Wikibooks. At the moment in the English version there are only nine books in categories that would be considered school-oriented textbooks—that is, excluding cookbooks, user-authored game manuals, and the like—that are at a stage that the Wikibookians deem either a comprehensive text or an advanced text. The rest are described as "maturing," "developing," and "sparse." These nine, in turn, are mostly written by a single author. Some others contribute proofing and cleaning up for Wiki presentation, but the histories of the modules do not generally exhibit genuine contributions in a co-authorship relationship of the type we see on Wikipedia definitions. The Cell Biology textbook is a project of one person, Mark Dalton, a computer engineer with an undergraduate major in biology, who started it on his own website. Karl Wick, the founder of Wikibooks, took it and opened it for others additions. The history page of the book shows that about ten people have indeed contributed over two years, but there have been very few additions, mostly dedicated to Wikification, not substance. The Sociology textbook is similarly the work of one person, Ryan Cragun, a graduate student at the University of Cincinnati sociology department. Other textbooks described as comprehensive are those concerned with the UK Constitution and the US constitution. Both are the work product of the same user, who works under a pseudonym. The UK constitution text has almost no other contributors except for spelling or typographical comment. The US constitution text has a few more users, but most of the text comes from the same user who authored the UK constitution text. The Physics study guide, explicitly not a textbook, and in "Advanced" rather than "comprehensive" state, apparently consists of Karl Wick's own notes as an undergraduate from his physics class. Paleoanthropology is again the project of one person largely, David Speakman, a freelance journalist. The two projects that do seem different in this category are in computer programming languages: Ada, with between one and three dominant participants, but also a substantial number of contributors, and C++, dominated by one user, but with more contributions, particularly in the last few months, from others. The fact that one or two users contribute an overwhelming majority of the work is not by itself surprising. The past few years have seen a large literature describing human behavior in free systems with individual action as often following power laws, rather than normal distribution. The point is, however, that there is also a long tail—a large number of people who make small contributions. That is the hallmark of a large scale collaboration that is capturing the talents and time of many contributors, rather than what is effectively a low-cost distribution system for the work of one or two individuals.

Wikibooks is not the only open textbook initiative that seems to be treading in place. The California initiative has an ambitious description on its website, but the actual project is located on Wikibooks, and does not even rank as an "active" book there. Indeed, its own pages describe it as a "placeholder." The history of the front page suggests that the page was originally placed there by Wick, who described the California initiative as including a "team of professional experts," but a few months later an anonymous user changed that description to the description that it carries at the time of this writing: that the page is a placeholder for a project, and that the project calls on all knowledge lovers to contribute to the California initiative. There is, as of the summer of 2005, no substance to the one project that is identified as the placeholder—a world history textbook. Another initiative, "open textbooks," is for all practical purposes dead. The last entry of any form is from September of 2004.[viii]

Despite the generally discouraging state of open textbook initiatives, there are several successful, or at least moderately successful, initiatives. By looking at these we can begin to abstract what makes for a successful project, and what does not, and whether there is something about textbooks that makes the work particularly hard or less amenable to peer production. One reasonably successful project is the South African effort, Free High School Science Texts (FHSST). Founded in 2002 by a PhD candidate at the University of Cape Town, Mark Horner, the FHSST initiative is much more narrowly focused than the broader goal definitions of Wikibooks or the California initiative, much more "managed," and much more successful. It is also therefore much more traditional in its mode of operation, or its divergence from the commercial model is less radical, except in one all important factor—all the participants are volunteers, and their output is distributed freely under the GFDL—the GNU Free Documentation License. The initial project focused on three main textbooks: physics—the discipline of Horner and his primary partner in leading this project, Spencer Wheaton—chemistry, and mathematics. The physics book is almost complete, reflecting the fact that all the administrative team members are physics graduate students. The other two are more than half done. New projects, in life sciences and computer literacy, have been launched in the second quarter of 2005 in Wikibooks, but have not yet attracted contributions in any significant degree. At the moment there seem to be slightly over 80 contributors credited, but many of the contributors have contributed once, or not really contributed much at all.

At the core of the effort is a team of "administrators," most of whom have been working on the project for three years.[ix] This team provides the driving force and continuity for the project, sometimes in the face of months of no or little progress. The core team goes out every few months and recruits volunteers by posting on various mailing lists. Each time they get about five to ten volunteers. Volunteers range from university professors to undergraduate students. Each volunteer will exchange information with the administrator for the book on which they have volunteered to work. The volunteer provides information both about their technical equipment and, more importantly, their substantive competencies and their preferences for working. The administrator will then try, but not always succeed in, assigning a module to the volunteer that is closest to what they wanted to work on, or to persuade them to work on something else that is within their competence, if what they are interested in doing has already been done. The administrator will also give the volunteer detailed instructions, backed out of the state's requirements for textbooks, about what needs to be in the module and what the students must be able to achieve upon completing the module. Finally, the administrator will ask the volunteer to set a timetable for completing the work, and will follow up monthly for progress reports. Many of the volunteers seem to find that the workload is much higher than they expected and drop out, either before accepting a task or after failing to complete it, when it reverts back into the pool of "to do" modules. But over the course of three years enough volunteers have in fact delivered that the physics textbook is now almost ready for review and use by the academic establishment—a precondition to its adoption by the government. When a volunteer concludes their part, the chapter will circulate to other editors for editing, and finally the whole chapter, usually made of several modules, will go to a single author for smoothing out the differences in style and emphasis.

The main problem with even a successful project seems to be that textbooks that look and feel like textbooks, and, more importantly, that comply with education department requirements, are not quite as susceptible to modularization as an encyclopedia or a newsletter like Slashdot. The most successful book on Wikibooks, for example, is the cookbook. But the cookbook had 1301 "chapters" as of July of 2005. In other words, each module was effectively a single recipe. In this, it is much more like Wikipedia, with discrete, small contributions as the minimal module. Real textbooks appear to reside somewhere between a novel and an encyclopedia in the degree to which they can be modularized, or at least in the degree of effort required to integrate the modules into a coherent whole recognizable as a textbook. Moreover, the chunks or modules seem to be bigger. It is very hard to add a single sentence, although it may be possible to add a single example or a better-rendered equation or chart. In the FHSST, for example, modules will run from 8-20 pages, covering a single principle. Horner assesses that for those among the volunteers who are most up to date, and teach the module's materials on a continuous basis, this would reflect at least a ten hour commitment. Chances are for most anyone else, and perhaps even for the most knowledgeable of volunteers, that writing 8-20 pages of textbook materials, diagrams, and problem sets is a much larger time commitment. And that is the smallest unit of contribution. The problem, Horner explains, is that integrating and smoothing out the text, style, and coherent structure of a chapter from contributions in much smaller tasks becomes much harder. The result of making the modules more fine grained may be to make the integrated whole too difficult to render coherent. This insight fits with the observation that most of the successful projects on Wikibooks are written for all practical purposes by one person, or at most by a group of collaborators that is orders of magnitude smaller than the larger peer production projects like Wikipedia or Slashdot, and even these have a strong and highly active guiding hand from a primary contributor or two. In the case of Ada, for example, two or three devotees of the programming language produce almost all the textbook, and "market" the work on various mailing lists as part of their ongoing effort to evangelize for the open source programming language, of which they themselves are major contributing developers.[x] Because of this characteristic, the potential for "the leader" to make mistakes and alienate potential contributors is higher than in the more fully distributed projects. As the leader has written much of the original text, and continues to overlay his or her framework on the textbook as a whole, other participants can feel left out, excluded, or overruled. In smaller groups, with leaders who are relatively good at masking their own egos and can weave contributions of users into a collective work of authorship, textbooks can succeed. But it does seem that a greater individual commitment to a large contribution is necessary in the context of such a coherent whole as a textbook than it is in the context of information goods that can be more thoroughly modularized into genuinely independent objects integrated through the use of the user.

It is not in theory impossible to get around this problem by modularizing the integration function itself. Horner, for example, is considering a new system based on xWiki that would allow the implementation of a system with much smaller chunks, that would not be posted into a text, but into a database for peer review moderation. These, in turn, would be moderated, accepted, edited and or included. Such a system would also require integration of a reputation system, through which authors who contribute regularly and at high quality can be recognized by the system and given a greater role in moderating and editing the text so as to smooth it out. The trouble with such controls, however, is that they make it harder to capture the power of very large numbers of contributors. Indeed, the question of the extent to which Wikipedia would be and remain free for anyone to edit, with or without logging in, and without hierarchical preference for "authorized" and authoritative users was a critical, self-conscious, and contentious decision at the early stages of Wikipedia. It led Larry Page, who had been originally employed by Jimmy Wales to edit and set up the encyclopedia, to leave and vociferously criticize Wikipedia from the outside. But it turned out to have been a critically successful organizational choice. Whether greater modularization does indeed require tighter technical controls on contribution to maintain consistency, or whether in fact, the greater the modularization the lower the barriers necessary because no single contributor is likely to make a very large mistake, and because the contributions of many are required to move the project forward in these newly-smaller chunks, is a critical design question for the next phase of open textbook development.

At the moment, however, no working project has in fact implemented a platform that modularizes the work in sufficiently fine-grained chunks to allow a large pool of contributors. As I have elsewhere discussed in great detail, the size of the potential pool of contributors, and therefore the probability that the right person with the right skills, motivation, and time will be available for the job is inversely related to the granularity of the modules. The larger the granules the more is required of each contributor, the smaller the set of agents who will be willing and able to take a crack at the work. On the other hand, the granularity is determined by the cost of integration—you cannot use modules that are so fine that the cost of integrating them is higher than the value of including the module.[xi] The case of textbooks seems to be, at present, precisely at the stage where the minimal granularity of the modules in some projects—like FHSST—is too large to capture the number of contributions necessary to make the project move along quickly and gain momentum, whereas the cost of integration in others, like WikiBooks, is so high that most of the projects languish with a module here, and module there, and no integration.

Note that this problem is particularly acute for K-12 textbooks, more so than for college textbooks. With the former, the textbooks are usually chosen by someone other than the teacher. In many countries and many of the United States, the book is chosen at a national or state level. Even where this is not the case, books will largely be chosen at the local municipal or system level, not by each teacher mixing and matching their own materials. As a result, the textbooks need to be a coherent whole of a certain character, complying, as in the case of the South African FHSST project, with a set of known national requirements. In the United States we see a highly concentrated market providing K-12 textbooks, and whose main providers specialize in lobbying for specific adoption of their books and homogenizing their contents to fit states with very different political and cultural goals in education. The result is that textbooks for this segment need to be systematic, coherent, and compliant with well-defined external constraints. By contrast, at the college level, the culture is very much one in which individual instructors may collect and create their own materials. As a result, a project like MIT's Open Courseware Initiative can succeed.

The MIT Open Courseware (OCW) Initiative is the most successful in this domain—providing syllabi, lecture notes, problem sets, etc. from over 1,100 courses. Taken on as a strategic move by the MIT faculty and administration, and funded by the Hewlett and Mellon foundations, the MIT OCW has a very different structure than do the peer production efforts. Here, the basic creators of the materials are the teachers themselves. They are fully paid academics, who must produce materials for one of their core professional roles: teaching college and graduate level courses. For some who do not prepare lecture notes that can be distributed, there may be some added work involved, but by and large the content is a "side-effect" of teaching. Instructors are not required to, but many do then volunteer to contribute their course content into the collective initiative. What is left then to be done is to integrate, create easy interfaces and search capabilities, etc. While these are nontrivial, again, in the context of MIT these functions are performed on a traditional model—a large, well funded nonprofit provides an important public good through the application of full time staff aimed at non-wealth-maximizing goals. The critical point here is the radical departure of MIT from the growing and prevailing culture of the 1980s and 1990s in American academia—to try to make money whichever way one can. When other universities were thinking of "distance education" in terms of selling access to taped lectures and materials so as to raise new revenue, MIT thought of what its basic mandate to advance knowledge and educate students in a networked environment entailed. The answer was to give anyone, anywhere, access the teaching materials of some of the best minds in the world. Because the initiative is not intended for adoption in pre-college educational systems, there is no need to impose a well-defined selection criterion for inclusion and exclusion. The users of the materials are either college/university-level teachers or self-studiers who use the materials. In both cases it is up to the users to construct, integrate, and use the materials as fits their needs. No higher order organization is required, and none therefore represents a barrier to contribution. As an intervention in the ecology of free knowledge and information and an act of leadership among universities, the MIT initiative was a major event. As a model for organizational innovation in the domain of information production generally and educational resources in particular, it was a much smaller move.

A different type of higher-order learning tool or set of materials are immersive environments—like multiplayer online games—which may be usable as training and immersive education platforms. This part of the discussion is more speculative at this stage, because no clear open platform has emerged as a common platform for development. The basic idea is that there are opportunities for educational uses in immersive 3D collaborative environments. If physics can be tweaked with visualized results to different parameters, if teachers and students can all share a visual space with easily manipulable objects, if students can point, tweak, ask or answer, if materials can be co-edited, we begin to have a very rich potential platform for educational interactions. It is relatively easy to visualize what these would look like based on the experience of multiplayer online games. These persistent environments allow many thousands of users to co-habit a persistent environment, create, manipulate, and exchange objects that others then see has having been created, changed, or used. In one, *Second Life*, a "university" has in fact been created, in which some courses on in-game design, but also in programming more generally are being given. The questions around the long-term importance of this medium from the perspective of production can be divided into two. First, there is the question of the extent to which the platform or engine will be developed in an open, collaborative way. The second is whether, if this precondition is fulfilled, there is reason to think that richly-rendered learning objects and educational experience contexts will in fact be developed for this platform. My tentative and speculative answer to both of these questions is yes.

The first question is one of software design. We have already seen that software development is amenable to peer production. Current informal discussions on the Net about whether or not this is possible tend to conceive of the project as "building a massive multiplayer online game."[xii] Concerns expressed regarding feasibility of open development include claims that artists, unlike software developers, are more proprietary about their work, that storylines are necessary and require a coherent teller or tellers, and that the service of maintaining the servers where the persistent environment exist are too expensive to maintain on a nonmarket model. One source of answer to these concerns is the experience of Second Life, a commercial game whose developers focused on improving tools only, not content. As a result, the roughly 40,000 users of Second Life have developed over 99% of the objects in the game, and all the story lines. As a result, the supposed need for artists and storyboard developers who will feed the users narrative and challenges reflects a narrow perspective of whether open development of the kinds of popular games now played will succeed. But that is not the interesting question. The interesting question is whether the tools and platforms necessary to create richly rendered immersive environments for collaboration is feasible on an open model. If it is, we would only be left with the question of physical equipment. The solution to the equipment necessary for maintaining persistent multiuser environment is clearly in the peer-to-peer capacity sharing systems. Here we have the example of Skype, the peer-to-peer Voice-over-IP application, the peer-to-peer file sharing networks themselves, and distributed computing projects like SETI@Home. In each of these demanding applications, data storage, manipulation, and retrieval, as well as communication, is done through radically distributed peer-to-peer architectures that use the excess capacity of the computers owned by the users instead of a proprietary infrastructure. There is no fundamental reason to think that this cannot be done for a persistent collaboration 3D environment.

There are in fact several open source projects that are working in the direction of creating such an open platform. None, as of the middle of 2005, have in fact reached a stage where they are used in educational settings. Nonetheless, the most ambitious, and most promising of these is the Croquet Project.[xiii] Croquet is an effort to construct an operating system from the ground up with the assumptions of high bandwidth communications, high-capacity processors, and pervasive collaboration. It is led by some of the best known early developers of personal computers, interfaces, and networking architecture. It is open source. It is allied with twelve major universities in the United States, Japan, and Germany. And it is constructed from the start to be a multi-user, networked, learning platform. Current design goals and demonstration illustrations show how the platform could be used to allow teachers and learners to take a "field trip" to Mars, or all interact around a manipulable 3D rendition of a molecule they are learning about. Critical for the development over time of modules, the "universe" of objects can be made either available for all to see—like web pages—or limited based on authorization. In principle this should allow an educator in one place to spend time creating a learning environment and then, just as he or she can today with an object on a web page, make that 3D learning environment or objects available for others to use, copy, modify, etc. The project has all the characteristics of a successful open source project. It is "ready" enough for people to work with. It is breathtakingly ambitious, providing plenty of kudos for those who contribute, and plenty of training and reputation effects if they do so successfully. Unlike a textbook, and like other software, it is highly modular in its tasks, and able to capture a wide range of contributions, at least in principle. Whether the leadership group will succeed in collecting that group over time will remain to be seen, as a practical matter. But there seems no systematic reason why this project, or one like it, cannot succeed.

This brings us to the second question, of whether or not, given such an open engine, educational materials, learning objects and contexts will in fact be authored, by whom, and with what degree of openness to further extension. Here the answer seems to be similar to the answer for learning objects, as compared to textbooks. A platform like Croquet, just like the Second Life platform in the commercial world, allows users to take existing materials, modify them slightly, and have the modification be part of the existing space for all users. This means that objects can grow and develop over time with small incremental improvements by many users, without limit. Certainly as long as this space remains unregulated so that no "minimal coherence" or completeness is imposed before a space or object can be used, these can be permitted to grow over time and self-organize into topical or contextually-bound learning platforms. In order to achieve this, however, it will have to be part of the design imperative of any such project to make the creativity tools within the environment highly user-friendly: just as the tools in Second Life are adapted to even unsophisticated users. Once this is in fact in place, there is no clear need for a coherence-imposing order, except a mechanism for searching, sharing, and modification. The growth trajectory is more like that of websites on the WWW than for textbooks.

Conclusion

The networked environment seems to have successfully released enormous creative energy in domains ranging from software design to encyclopedia writing. It has come, in many cases, to compete with and outperform traditional proprietary, market-based production. The question we face is whether the basic economics and organizational strategy that have proved so successful in other areas are equally applicable to learning objects and other educational resources. The answer seems to be: it depends.

The "raw materials" of decentralized, nonproprietary development of open educational resources are there, ready for use. Computers and network connections are ubiquitously distributed throughout the network and around the globe, at least in advanced economies. Teachers, learners, graduate students, and amateurs populate the network in their millions, with diverse abilities, availability, time, and attention to spend on developing bits and pieces of educational resources. The critical question then becomes the character of the products themselves. In particular, what matters is whether they are sufficiently modular, extensible, and capable of incremental small scale improvement to benefit from the economies of scale of large numbers of contributions in small quanta.

For most educational resources, the answer seems to be that they are amenable to peer production. The critical question is whether we have sufficiently good search engines and integration platforms to allow learners and teachers to search, use, and contribute back these learning objects and distributed educational resources. For those educational resources, in particular textbooks, which are under administrative supervision, however, the problem is more difficult to resolve. Because of the nature and cadence of a textbook, in particular the requirement that it adhere to state-set standards, that it be approved as such, and that these be adhered to in a way that is coherent throughout the book, there may be basic limits on the degree to which a genuine K-12 textbook can in fact be organized for peer production. Because of the importance of textbooks and the lack of textbooks in poorer countries, however, this problem is a really important one, and worth working at. The question is whether a new type of interface, with smaller chunking of materials but relatively easy editing and smoothing out could take the place of the current model, where textbooks are mostly authored by individuals or, as in the case of FHSST, a group of very idealistic and dedicated graduate students. On the other hand, the other type of coherent, large-scale educational resource development project—multi-user collaborative platforms—these seem to have similar characteristics to software development, and should, eventually, be susceptible to peer production. Once they are, objects within them have similar characteristics to objects on the Web, and therefore should be amenable to both coordinate and cooperative peer production.

Open development of educational resources promises significant benefits over commercial development. It can tap many more contributors. It can avoid the pitfalls of too heavy an emphasis on pleasing large numbers of school districts and teachers with a standard product, as opposed to producing many narrowly-tailored high-end learning objects that can then be integrated differently by different teachers and learners, according to their own needs, styles, and emphases. From the perspective of global development and education, open approaches to the creation of educational resources, particularly those that would be appropriate for use in poorer areas, would at a minimum benefit from an influx of creative and knowledgeable contributors who require no exclusivity in their outputs, and who do not necessarily focus their efforts on markets able to pay the most. But it is not equally available for all tasks. Learning environments with greater teacher and learner autonomy will benefit from the kinds of materials that can be generated best by a collaborative network more than more tightly controlled learning environments, where the materials are required to cohere on a large scale with a pre-defined framework set by someone other than either the developers or the learners/teachers.

[i] See Gilbert T. Sewall, Textbook Publishing (Ph Delta Kappan 2005), and Steve Forman, *Textbook Publishing, and Ecological View*, Journal of American History, 91(4), 1398-1404 (March 2005).

[ii] UNESCO, Basic Learning Materials Initiative, A guide to sustainable book provision (UNESCO 1997).

[iii] David A. Wiley, II, Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy, see http://www.reusability.org/read/chapters/wiley.doc.

[iv] For a review of this literature and notes to it see Yochai Benkler, Sharing Nicely: On shareable goods and the emergence of sharing as a modality of economic production, 114 Yale L. J. 273 (2004).

[v] For example, http://elearning.utsa.edu/guides/LO-repositories.htm provides a list of depositories.

[vi] Quoted in its 2001 formulation in Yochai Benkler, Coase's Penguin,or Linux and the Nature of the Firm, 112 Yale Law Journal 369 (2002)

[vii] IBM Collaborative User Experience Research Group, History Flows: results (2003), available http://www.research.ibm.com/history/results.htm.

[viii] http://bat.vr.ucl.ac.uk/opentextbook/.

[ix] Much of the factual information comes from an interview with Mark Horner, July 28, 2005.

[x] Email exchange with Martin Krischik, July 30, 2005.

[xi] Yochai Benkler, Coase's Penguin or Linux and the Nature of the Firm, *ibid.*

[xii] A particularly useful sample can be observed on Slashdot at http://ask.slashdot.org/comments.pl?sid=148104&threshold=1&mode=thread&commentsort=3&op=Change

[xiii] http://www.opencroquet.org. Detailed white papers available at http://www.opencroquet.org/About_Croquet/whitepapers.html.