Collaborative Learning 2.0:

Open Educational Resources

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Chapter 15
Crowdsourcing Education on the Web:
A Role-based Analysis of Online Learning Communities

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ABSTRACT

Learning online has significantly evolved over the past decade due to the emergence of Web 2.0 and 3.0 technologies that facilitate social learning in adaptive online environments. The open content movement and the associated techniques of crowdsourcing (i.e. assimilating several small contributions into resources of high quality) have further influenced education on the Web. This chapter investigates the concept of crowdsourcing in education through an analysis of case studies dealing with two open online learning communities, Peer 2 Peer University, and PlanetMath.org. The case studies proceed via an analysis of the various roles played by the individuals involved in each organization. The outcomes of this analysis are used to extract general recommendations for building online communities and applying crowdsourcing techniques in educational contexts.

INTRODUCTION

Web 2.0 and 3.0 technologies are transforming the landscape of learning. These technologies enable learners and pedagogues to co-produce learning environments that adapt to the competencies and motivations of each participant. Building these systems online, in the open, system developers and curriculum authors can make use of both high-intensity, high-cost contributions, and a long tail of smaller and less intensive contributions. This process of assimilating many small contributions into resources of high quality – colloquially known as crowdsourcing – is becoming a key aspect of

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the development of open online learning platforms. The challenge inherent to such efforts is to capture the surplus value of distributed processes of social engagement in a way that permits reuse and further development.

This chapter rethinks Nonaka and Takeuchi's well-known SECI model of knowledge creation (Nonaka & Takeuchi, 1995), and applies it to two case studies in crowdsourced education. The revisions to the SECI model are two-fold. First, what initially appears to be a simple and intuitive shorthand, obtained by mapping Nonaka and Takeuchi's Socialization/Externalization/Combination/Internalization onto Ken Wilber's I/We/Its/It (Wilber, 1997), upon further reflection leads us to a very different way of thinking about things. And, second, Nishida's philosophy of *basho* (summarized in English by Masao Abe (1988)), which was a noted inspiration for the SECI model, plays an even more central role in our version of the theory.

To put it somewhat colorfully, the "Golden Age" SECI is here updated to make it suitable to the analytical challenges present in our "Modern Age". These challenges include organizations that make significant use of commons-based peer production (CBPP) (Benkler, 2005), organizations without a traditional management structure, and collaborations that cut across organizational boundaries. The focus in our analysis is on the various social roles taken on by the persons involved in such settings.

A point of departure for our new understanding of SECI is the critique found in Engeström's "Innovative learning in work teams: Analyzing cycles of knowledge creation in practice" (Engeström, 1999). Engeström makes a convincing case that "SECI" really doesn't adequately represent a cycle, despite the claims of its initial creators. The I/We/Its/It framework doesn't represent a cycle, either. Rather, we use Wilber's terms to describe a given *social role* in terms of its *constituent actions*. So for example, the role of "being a student" might be described as follows:

"I go to class, we do a class project, the objects of concern ("Its") are things I can add to my portfolio or work-record; and fundamentally it is all about gaining a skill."

This simple background story gives us a notion of role, persona, or identity: a role that is defined by its constituent actions, relative a given social context. And here, context is conceived of, after Nishida, as a "shared context in motion" (this is the meaning of the term "*basho*").

Our little story describing the role of a student doesn't have much to do with "knowledge creation" or "epistemic action". Still, now that we have a convenient way to talk about roles, we can move on to talk about how roles can change over time, how new roles come into existence, how different roles can conflict, and so on. It is in this respect that we recover the organizational learning dimensions of the SECI model – not as a byproduct of individual learning cycles, but as a complex of ongoing adjustments to the shared context and the social roles that are enacted therein (Engeström, 2007).

Thus, our concern is with the way a given context creates and is in turn created by its constituent social roles. Using this approach, we will develop a theory of organizational learning that is applicable to contemporary educational communities, possessing all of the complexities of our "Modern Age".

The next section will set the stage by looking broadly at contemporary education and its many stakeholders. We then present a case study centering on an informal course that the first author ran at Peer 2 Peer University in Autumn of 2010[1], followed by a second case study, which applies our model to look at possibilities for organizational change in the community-created online mathematics community, PlanetMath.org.[2] We conclude the chapter with some general recommendations gleaned from reflections on these two case studies.

Table 1. Sketch of the social roles in a traditional university

I.	*I* go to class, *we* do a class project, *the various aspects of which* are things I can add to my portfolio or work-record; and *fundamentally it's all about* gaining a skill.
II.	*I* lead a class, *we* plan and implement the curriculum, *my work involves* giving lectures and feedback and, more infrequently, meetings with my colleagues; and *fundamentally it's all about* helping my students.
III.	*I* ask a thought-provoking question, *we* discuss or experiment, *the results* are written up in papers; and *fundamentally it's all about* generating new knowledge.
IV.	*I* transform ideas into code or policies, *we* collectively manage a body of work, *the pieces* are the components of a functioning system; and *fundamentally it's all about* creating a workflow that works.
V.	*I* engage in dialog, where I promote a certain position, *we* try to find common ground, *the results of* various interactions and transactions are assembled into strategies; and *fundamentally it's all about* creating a distinctive organizational identity and strong partnerships.
VI.	*I* endeavor to discern societal needs, *we* work to achieve a rough consensus with a larger body of stakeholders, *the results* describe a certain clearly-defined skill set; and *fundamentally it's all* about knowing the appropriateness and relevance of a certain training process.

BACKGROUND: EDUCATION AND ONLINE COMMUNITIES

We begin with a look at how educational communities are built. A traditional university, for example, is populated by students, teachers, researchers, administrators and staff, and possesses a certain legal status by maintaining a relationship with accreditation bodies and government. We get a sense of the dynamics of the university when we look at the actions that comprise these roles (Table 1).

These sketches shouldn't be taken to be definitive, but rather, as paradigmatic. It seems reasonable to say that any social setting that supports actions sufficiently like these is an "educational context". A setting that intersects only a few of them (e.g. an academic publishing house) nevertheless forms part of the broader social context in which education sits.

This leads to the idea that a given educational context can be distributed in space and time in various different ways. Many of the support functions related to infrastructure can be subcontracted or otherwise outsourced. For example, instead of giving lectures in person, an instructor may deliver lectures via podcast.

It is in this distributed setting that Open Educational Resources (OER) arise and become relevant to the future of education. We are concerned in Table 1 with *social* roles, and various social contexts arise to support these as well, ranging from study groups, to tutoring services, to "virtual colleges", to open source software developer communities, to professional associations, all the way through to UNESCO.

In many cases it is not suitable to view such settings as only "ancillary", as they are significant communities in their own right. For example, Wikipedia is more than just an encyclopedia: it is effectively the flagship of a social movement.

Educational Communities, Online

Two well-known sources of educational content are Connexions[3] and MIT OpenCourseWare[4]. But while both Connexions and MIT OpenCourseWare contribute to the broader commons of OER as production communities, they appear to use commons-based peer production (CBPP) in a limited way. To illustrate the point: at the time of this writing, although thousands of people visit the Connexions website each day, discussion forums are not present on this site. Instead, the (essentially broadcast-based) Connexions blog is the central "community" feature[5].

Table 2. We are in between several familiar institutions and a couple others that are less familiar.

	Solo consumer	Mediated sociality	Social consumer
Highly modular	Library	Gutenberg.org 2.0[6]	University
Lightly integrated modules	Encyclopedia	OER communities	Course
Highly integrated	Book	Interactive Hypertext	Tutor

In Table 2, we suggest that consumers of OER exist in a realm in between that of the "solo consumer" and that of the "social consumer"; and that OER resources typically lie in between "highly integrated" systems and "highly modular" systems. This, together with a suitably broad understanding of openness, can make peer production of OER a natural choice.

In the next two sections of the chapter, we will examine two distinct educational communities, Peer 2 Peer University (P2PU), and PlanetMath.org. The former is building a social platform, together with a collection of best practices related to running peer-based courses online and a collection of course materials from previous courses. The latter is building a mathematics encyclopedia with integrated discussion forums, and, at present, has essentially nothing to do with courses or course materials per se.

We can imagine a team-up in which PlanetMath provides content and supports learner interactions, whereas P2PU provides training training to course organizers in the important non-mathematical skills for running an effective course, as well as a certification layer for course participants. The following sections will examine these two cases using an approach similar to the role-based analysis of Table 1, but they will go into much greater depth.

P2PU CASE STUDY: "ONLINE BOOK CLUBS FOR OER"

Overview, Objectives, Challenges

This case study is based on the experiences of the present first author as the facilitator of an online course called "DIY Math" that ran through the Peer 2 Peer University in Autumn of 2010. The interactions in and surrounding this course provide a lens on P2PU as a whole.

We will now present some background information on P2PU and the design of DIY Math. From the P2PU website:

The Peer 2 Peer University is a grassroots open education project that organizes learning outside of institutional walls and gives learners recognition for their achievements. P2PU creates a model for lifelong learning alongside traditional formal higher education. Leveraging the internet and educational materials openly available online, P2PU enables high-quality low-cost education opportunities.[7]

The Shuttleworth Foundation, who sponsored P2PU early on with a $30K fellowship, provides the following description of the organization:

The Peer 2 Peer University (P2PU) is an online community of open study groups for short university-level courses. Think of it as online book clubs for open educational resources. The P2PU helps you navigate the wealth of open education materials that are out there, creates small groups of motivated learners, and supports the design and facilitation of courses. Students and tutors get recognition for their work, and we are building pathways to formal credit as well.[8]

Although P2PU has only been online since 2009, they have gathered significant media attention and interest. They describe themselves as an online community of about 1000 persons. Many of P2PU's core volunteers are also affiliated with other organizations in the open online education space. The P2PU approach is to be "open" to nearly any constructive form of participation. They are in the process of making their "horizontal governance" structure more clear, at the same time as they pursue formal incorporation and non-profit status. They are presently experimenting with a range of learning and communication technologies. They were enthusiastic about adding a mathematical course to their range of offerings.

The DIY Math course itself was designed to deal with the question *how should we build a course that supports both independent and peer-based mathematics learning?* By being expressly open to "mathematics learners at all levels", DIY Math followed a very atypical approach to the teaching and learning of mathematics. The rationale behind this was that learners would eventually self-organize a support system. Accordingly, the syllabus did not include specific mathematics topics or exercises, but rather, certain general suggestions regarding collaboration:

- be ready to introduce yourself and your interests in the mailing list by the time the course starts;
- reply to at least one other person's self-introduction to say how it relates to your own interests;
- come up with some candidate discussion guidelines or objectives;
- update the group when you start looking at a new mathematical resource;
- give a review saying whether you found that particular resource helpful or not, and why;
- post short summaries of any study strategies you're using;
- post reviews of your strategies;
- identify one or more study buddies who are interested in topics similar to the ones you're most interested in;
- post in response to one of the two prompts that follow: "Tell us about something you learned."; and/or "Tell us about something you're having difficulty with."

Twenty-two people initially signed up for the course, and their applications alone were enough to generate some useful reflections. In particular, they provided a first impression of the mathematical interests of the would-be participants. Despite the initial show of (wide-ranging) interest, less than half of these people made it past the hurdle of "self introductions", which were to take place in the course's Google Group.[9]

By the second week, things had already gotten pretty quiet. Although the essence of "DIY Math" had been made reasonably clear to the participants, this did not translate into anything resembling a serious commitment. To generalize from this experience:

1. *When organizing an event or setting up a context for any given social activity, it is a really good idea to ask people what they would like to do there*; and
2. *It is equally important to get the participants to commit to follow through on actually doing*
3. *what they said they are interested in* (if their commitment is insufficient, the description of the activity should be revised and commitments renegotiated accordingly).

The experience with DIY Math shows that the idea of self-organization alone will not create a successful peer-to-peer learning environment. In a traditional educational setting, there are a variety of factors (e.g. money, credentialization, informally enforced norms) that could help create a sense of commitment on the part of learners: by default, these are wholly missing in informal learning.

In P2PU at present, a lot of the "pull" comes from facilitators who not only decide what courses to run, but who also are charged with keeping the peer learners engaged, and contributing to a body of knowledge about how this can work best. In this organization that places a strong value on non-hierarchical peer relationships, at present, the importance of the complex role of course facilitator is "not to be under-estimated".

Role-Based Analysis

Tables 3-7 present several different roles associated with DIY Math and P2PU more generally. These are:

- The role of an an "ideal" participant in the DIY Math course (i.e. based on how things were supposed to work, according to the syllabus);
- The role of a more realistically-conceptualized participant in the DIY Math course (how things *actually* worked for most people);
- The role of a facilitator at P2PU;
- The possible future role of a peer learner in a structured "Short Calculus" course taught at P2PU;
- The possible future role of an "arbitrary participant" in P2PU where the organizational structure has become flatter.

Lessons Learned

The flattening of roles in Table 7 is potentially surprising. The insight embodied in that gesture is as follows.

If P2PU was taking an ongoing survey of the "wished for" course topics, a future course organizer would presumably be able to create courses specifically tailored to the interests of pre-self-selected participants. Alternatively, interests could simply be listed ("social network style") on user profile pages and aggregated in an intuitive way. Levels of commitment could similarly be specified in advance, ranging from "I'd like to put 1 hour a week on this topic" to "I'm available to work on this full time." Detailed qualitative aspects of commitments could also be specified (e.g. "I'm willing to answer questions about Calculus but keep in mind I haven't taken it for a few years").

The key point is that the system could then be set up so that courses only would only run when sufficient interest had gathered. This design would use the idea of "shared context in motion" to help relationships form organically, and to emphasize the importance of appropriate commitments for building trust.

Another lesson is that a participant in a structured course like Short Calculus (Table 6) might benefit from the existence of an unstructured support system, something like DIY Math. This approach is consistent with the idea that a peer-based community doesn't easily arrange itself into explicitly delineated and wholly "visible" structures, but may instead have a lot going on in the background (Engeström, 2007).

Recalling the vision of "online book clubs for open educational resources", the possibility that a facilitator need only be very slightly involved again suggests itself. There appears to be a certain degree of trade-off between the time and energy spent preparing course materials, and the time and energy spent facilitating the course. (From the point of view of Table 1, part II, this is the difference between what "we" do together as

Table 3. The role of an "ideal" participant in DIY Math course

I	say what I want to study
We	talk about difficulties and successes
Its	discussions on a shared mailing list
It	helps me learn mathematics (and improve my skills at being a self-directed and peer-to-peer learner)

Table 4. The role of a more realistically-conceptualized participant in the DIY Math course

I	try to figure out what to study
We	sometimes give or get advice that isn't always so helpful (and most of it isn't for me, anyway)
Its	a bunch of good intentions that lead nowhere
It	confirms my sense of the difficulty of learning anything in a self-directed fashion (and the difficulty of mathematics in particular)

Table 5. The current role of a facilitator at P2PU

I	come up with a course I'd like to facilitate, and then facilitate it
We	discuss ideas about how our courses might work and what "facilitation" means (e.g. as opposed to "teaching")
Its	discussions on a community mailing list and other settings (including discussions with participants in the course as it runs)
It	helps me improve my skills at a course designer and facilitator (and it's fun talking about and practicing this stuff!)

Table 6. The possible future role of a peer learner in a structured "Short Calculus" course at P2PU

I	work on calculus problems from the syllabus and ask questions in an appropriate venue when I get stuck
We	talk about difficulties and successes and examples
Its	discussions on one or more shared mailing lists or forums
It	helps me learn calculus (and develop some good study habits along the way)

Table 7. The possible future role of an "arbitrary participant" in P2PU

I	describe what I'd like to learn or teach
We	constitute a class when we have gathered a enough interested peers with the right mix of skills; in the mean time, and in general, we constitute a broader learning community
Its	a marketplace of interests, skills, and ideas on the one hand, and efforts, attempts, and assistance on the other
It	helps me learn what I want to learn and have fun in the process

teachers, and what "I" do as a teacher.) It is conceivable that the best facilitator would not be an expert in the course's subject matter, but an expert in peer-supported learning per se.

In Winter 2011, the first author facilitated three more courses at P2PU, with mixed results, which nevertheless appear to strongly support the perspectives outlined above. One useful outcome of these experiences is that we have significantly improved our theory of peer-to-peer learning (summarized in the section entitled "Paragogy", below).[10]

PLANETMATH CASE STUDY: "MATH FOR THE PEOPLE, BY THE PEOPLE"

Overview, Objectives, Challenges

The scope of this case study is quite different from the one in the previous Section, since here we will look in overview at the last 10 years of PlanetMath.org, instead of the last few months.

PlanetMath came into being as the core of the work done by Aaron Krowne for his Masters degree at Virgina Tech (Krowne, 2003). On

PlanetMath, one finds the following statement by Krowne:

The idea for the project was hatched by [Nathan] Egge, sometime around fall 2000, in response to the unfortunate removal of the great resource, "Eric Weisstein's World of Math" (or "MathWorld") from the internet. This incident created a void for a useful, comprehensive math encyclopedia freely available online, which we wanted to fill as quickly as possible. So Nathan and Aaron began brainstorming the concept and working out many of the problems inherent in a system that would do in real-time what had been static on MathWorld. We also wanted to make certain that the users of PlanetMath would never have to worry about the removal of the content they had contributed in favour of commercial sale.[11]

Since its inception in the year 2000, over 11K encyclopedia articles have been contributed to PlanetMath, and over 14K posts have been made in the discussion forums. In recent years, the website has received 12-20K hits per day, the larger number when school is in session. It is worth noting that PlanetMath has many "competitors", the most obvious being Wikipedia, which went online in 2001, and also MathWorld, which has been *back* online since 2001. It is also worth noting that in fact a considerable amount of content has been *shared* in both directions between PlanetMath and Wikipedia under the terms of their common license, so in this sense they can be seen more as "collaborators" than as competitors. Another site that could be seen to compete-while-collaborating with PlanetMath is MathOverflow.net, a question and answer site hosted on StackExchange, and which, again, uses the Creative Commons Attribution-ShareAlike (CC-By-SA) license for its content.

At this point, while PlanetMath's content collection continues to grow, the growing number of competitors of various sorts, as well as growing opportunities for collaboration, serves to suggest that infrastructural development will be vital if PlanetMath is to have any significant success in its "next ten years".

Luckily, over the course of the past decade, there has also been a significant maturation of tools for dealing with mathematics, and a collection of such tools, developed by the KWARC research group at Jacobs University, in Bremen, Germany, now form the basis for a new software platform for PlanetMath that we call "Planetary" (David, Ginev, Kohlhase & Corneli, 2010). This technological leg up gives us a realistic opportunity to ask *what should PlanetMath develop into?*

For example, we could inject P2PU-like (or P2PU-hosted) courses into PlanetMath; assignments might include "write or improve a PlanetMath article" or "post questions and answers in the forum". PlanetMath could also draw more on other resources created elsewhere, as well as do more to share or mash up its resources and services with others (e.g. Wikipedia and MathOverflow.net; also with the popular mathematics preprint server, ArXiv).

All of these things should happen, and they will certainly change the context at PlanetMath. However, it is not entirely clear that such improvements will directly change the *roles* of PlanetMath users. By contrast, introducing *problem sets* into PlanetMath would create a whole new set of roles centered on creating, solving, and marking problem sets online. The persons engaged with such activities might be mathematics learners, volunteers, or paid tutors.

There are certainly other challenges we could take up, and many questions to answer along the way. In order to do this effectively, PlanetMath should round out its "open content" and "open source" communities with improved methodologies for doing *open governance*. Some important issues to decide will be our approach to *open data* (just what data will be open?) and more generally how PlanetMath will relate to the emerging field of *open science*. Our own involvement over the next couple of years will focus on the issue of problem sets, but the other ideas mentioned here are likely to find other champions within the community.

Role-Based Analysis

Tables 8-13 present several different roles associated with PlanetMath. These are:

- The role of a contributor to the PlanetMath encyclopedia
- Possible future role of a contributor to the PlanetMath's collection of problems.
- Possible future role of a person using PlanetMath as a place to solve problems
- Possible future role of a tutor on PlanetMath
- Possible future role of a "benevolent technocrat" on PlanetMath
- Possible future role of a "citizen programmer/hacktivist" on PlanetMath

Note that a "casual browser" or someone who only posts a few questions in the forum will have a profile that's very different from any of these. In particular, such a user's sense of "We" will likely have to do mainly with off-site relationships.

In light of this, it would be tempting to imagine that "producer" and "consumer" roles are quite distinct. But at least in some parts of PlanetMath, they tend to be closely combined. For example, one must actively engage with problems in order to solve them, and a consumer of problems tends to be a producer of problem-solutions.

Is a problem contributor (Table 9) significantly different from a contributor to the encyclopedia (Table 8)? At the very least, different motivations are likely to be near the surface (e.g. "altruistic" motivations centered on helping others learn; or perhaps an interest in the way the organization as a whole learns), but it also seems that the style of working is very different (e.g. creating a good problem, in this context, has more to do with connections between system objects than it has to do with "exposition").

Lessons Learned

If there is one clear lesson from the past 10 years of PlanetMath, it is that there is no shortage of great ideas out there. Unfortunately, there *is* a shortage of idea-implementers. The difference between Table 12 and Table 13 is meant to provide a view on that. These two roles differ only rather subtly, but the main idea is that we could in theory have many "citizen programmers", whereas at any given point in time, we are likely to have only a few "benevolent technocrats".

By building much of the new Planetary System in the form of modular extensions to the popular open source Vanilla Forums, we hope to make Planetary itself relatively easy to extend. To actually get people involved in the programming effort may require us to go quite a bit further, possibly even so far as to create a "PlanetComputing" where the Planetary System's code can be discussed and improved.

We hope that by making the development process more visible within future implementations of PlanetMath – and easier to get involved with – that we will be able to help people translate "ideas" into "incentives", and channel user input to a variety of increasingly useful ends. Some things that are difficult or impossible to achieve now should be fairly easy to deal with once more people are involved in the development effort. This will require careful ongoing analysis and design of social roles and contexts.

GENERAL RECOMMENDATIONS FOR BUILDING COMMUNITIES AND CROWDSOURCING EDUCATION

Comparing Crowdsourced and Traditional Education

One important question is to ask what differences occur between Tables 3-13 and Table 1, and in particular, whether crowdsourced

Table 8. The role of a contributor to the PlanetMath encyclopedia

I	write about things I'm interested in, in the form of encyclopedia articles
We	give each other feedback on the things that have been written so far
Its	a collection of articles, forum posts, and metadata
It	helps me learn mathematics (by giving me the chance to practice expressing myself clearly)

Table 9. Possible future role of a contributor to the PlanetMath's collection of problems

I	write or find and contribute problems that link together with other problems and with encyclopedia articles
We	help each other determine the context that is best-suited to a given problem
Its	a collection of problems and semantic links
It	helps me share mathematical understanding with others and helps me understand mathematics more deeply myself

Table 10. Possible future role of a person using PlanetMath as a place to solve problems

I	solve problems online and get help from encyclopedia articles, peers, or, if I want, a tutor
We	turn to each other for help when we see we have common interests
Its	a collection of exercises, articles, solutions, and metadata that's intended to support independent and peer-based learning
It	helps me learn mathematics much as I would in a traditional classroom (but I can go at my own pace and pick my own topics)

Table 11. Possible future role of a tutor on PlanetMath

I	get paid to answer questions
We	work together to create the best collection of resources for helping tutors answer questions (and helping learners work on their own)
Its	a collection of previous tutoring sessions, augmented with annotations and links created by us or others
It	lets me use my mathematical proficiency to make money and help other people

Table 12. Possible future role of a "benevolent technocrat" on PlanetMath

I	review usage data from the system, integrate this with feedback from the community, and implement systems that serve their interests
We	meet along the boundary between content and code
Its	a collection of policies and programs maintained on behalf of the user community
It	keeps the site alive (and, thanks to me, growing)

Table 13. Possible future role of a "citizen programmer/hacktivist" on PlanetMath

I	contribute to code development as part of my regular form of interaction with the site and the corpus
We	make decisions horizontally and have engineered out systems and policies so that no one person has much more power than any other (in particular, we've endeavored to widen out organizational bottlenecks)
Its	a collection of policies embodied in code
It	not only keeps our site running, but allows us to make further inroads into online education more generally

education is very different from traditional education or not.

The "student" and "teacher" roles are well represented in the model of crowdsourced education that we've developed. "Research" is *not* explicitly mentioned in any of our tables, but it certainly takes place, i.e. both research *about* crowdsourcing and peer-to-peer education, and also crowdsourced, peer-based, research on other topics, e.g. "Density Hales-Jewett and Moser numbers" by D.H.J. Polymath.[12] Building better support for this kind of massive collaboration – or even just better support for more tame computer-mediated research collaborations – is on PlanetMath's equally massive todo list. "Developer/administrator" roles are represented in Table 12, and an interesting blended "developer/advocate" role is described in Table 12.

In short, it seems that the only role from Table 1 that we haven't encountered in our analysis of P2PU and PlanetMath is the "accreditation body" role. Of course, it would be somewhat rare to find such persons embedded in a traditional university, since accreditation is importantly an "outside" role. P2PU has some innovative ideas about "peer assessment" and other strategies for measuring when learning is taking place, but these are quite a ways off from offering actual credits or diplomas.[13] They are also considering some team-ups with traditional institutions, where the outside institution grants credit to their enrolled students for work on P2PU.

In the case of PlanetMath, sufficiently rich and robust online problem sets should provide a clear sense of a learner's current state of knowledge; such measurements may in some cases be substitutable for a degree. At least according to our sketch in Table 1, it all depends on "knowing the appropriateness and relevance" of the training process. In some cases, this could be measured by learner performance on outside exams (e.g. AP tests, GRE subject tests, or perhaps even the Mathematical Tripos).

It would therefore appear that crowdsourced educational models at least have a chance of being as complete as the traditional model. Do they come with any additional benefits or constraints? The idea of a "a marketplace of interests, skills, and ideas" from Table 7 seems to have no ready correspondent in the world of traditional universities, except perhaps in a limited form, in the course catalog. At the same time, despite the broad popularity of social networks and the integration of some social networking functionality in both P2PU and PlanetMath, social networking on these sites is currently quite primative (simple questions like "find me a PlanetMath user who is interested in pedagogy" don't have easy answers).

Another major difference is in the issues surrounding commitment. Whereas students in traditional universities are presumed to be motivated by the prospect of earning a degree or certification, in informal education, a learner's prospects are entirely related to the skills they acquire, and to any enjoyment that comes from the learning process itself. If people need to be cajoled into committing, that isn't a terribly good sign. It seems it would be better if the learning environment itself facilitated involvement from people in the ways they feel suits them best. Perhaps incentives don't need to be created so much as "exposed" or "acknowledged".

General Recommendations

Different sites seem to exist precisely so that different modes of engagement will be supported. They certainly shouldn't be homogenized, and probably it's not even sensible to ask for them to be "rationalized". Rather, it seems important to design for a variety of different modes of engagement and patterns of use.

Because of the way we've framed the analysis, we've seen that there is a social dimension to every resource. These don't always have to be "open" in every sense to be successful. However, it seems likely that one way to open things up more, when desired, is to continue to do analyses of the kind we've done here: every organization can be mapped in this way, and can be examined for its potential *to support learning*.

It is useful to recall that a social context is defined by a variety of roles, and that roles often cross-organizational boundaries. Further, from the examples we examined, it appears that mixed approaches (a social layer *plus* preexisting resources; or, independent learning *plus* tutoring) have particularly strong potential.

At the same time, we should remark that a certain degree of cohesion in the learning platform ought to help make the *sharedness* of context more clearly felt. The question "how much cohesion is good?" seems to depend on the two factors most relevant to CBPP, integration, and modularity. Depending on what seems useful for the purpose at hand, a group of learners might be organized as a closed and seconded group, or as an open group embedded within a broader commons.

Licensing is one way in which groups become cohesive (and keep others out). Initiatives like MIT Open Courseware and OpenLearn[14] use a Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Licence; Wikipedia, PlanetMath, and P2PU use a Creative Commons Attribution-ShareAlike 2.0, and Connexions uses a Creative Commons Attribution 3.0 license. Licensing can powerfully change the way people relate to resources, especially when it comes to future re-use and/or modification.

An educational community may or may not seek to become sustainable. Sustainability could apply to features like growth, innovation, longevity, communication, and more, and it seems clear that a diversity of approaches must combine gracefully if prospects of sustainability are to have much hope. The style of analysis we have employed could help an organization define and create new roles to adapt to a shifting context.

Paragogy

One outcome of thinking about how to improve on the DIY Math course while building on the strengths of the P2PU organization as a whole is a new theory of peer-based teaching-and-learning, termed "paragogy" (Corneli & Danoff, 2011). Paragogy uses the "five principles of andragogy" stated by Malcolm Knowles as a jumping off point (Knowles, 1968, 1980). In super-succinct form, Knowles's five principles are: (1) that adults are self-directed learners, (2) that adult learners bring a wealth of experience to the educational setting, (3) that adults enter educational settings ready to learn, (4) that adults are problem-centered in their learning, and (5) that adults are best motivated by internal factors. A useful review and critique that goes beyond the soundbytes above is given by Laurie C. Blondy (2007). The five paragogical principles are:

1. *Context as a decentered center*. For learning design in a peer-to-peer context, understanding the learner's self-concept – in particular, whether they see themselves as self-directed or not – may be less important than understanding the concept of shared context in motion.
2. *Meta-learning as a font of knowledge.* We all have a lot to learn about learning.
3. *Peers are equals, but different.* The learner mustn't seek only to confirm what they already know, and must therefor confront and make sense of difference as part of the learning experience.
4. *Learning is distributed and nonlinear*. Side-tracking is OK, but dissipation isn't likely to work. Part of paragogy is learning how to find one's way around a given social field.
5. *Realize the dream, then wake up!* Paragogy is the art of fulfilling motivations when this is possible, and then going on to the next thing.

Paragogy can be fruitfully compared with another andragogy spin-off, heutagogy, a theory of self-directed learning (Hase & Kenyon, 2000). Because of its focus on the entire learning context, paragogy appears to intersect andragogy at 90 degrees, whereas heutagogy, with its focus centered on the learner, is 180 degrees away from paragogy. However, these theories do not seem to intrinsically conflict with one another, even though they offer very different views on education.

We feel that paragogy provides a useful philosophy for the advocate and practitioner of crowdsourced education, and that, together with role-based analysis proposed in this paper, it can be valuable addition to the world of OER and open online education. More generally, paragogy and its concept of the peer production of the learning context can open a new window on the ideas of organizational learning coming from the classical SECI model.

CONCLUSION AND OUTLOOK

The chapter describes the various social roles of the individuals involved with P2PU and PlanetMath.org, and envisions future roles that could be created at these organizations. We hope that our analysis will help inform the relevant design, implementation, and governance decisions.

In addition, we compared crowdsourced and traditional education and found that the crowdsourcing model has room for most, if not all, of the roles found in the traditional setting, accreditation and assessment being a key area where there are no definitive answers as yet. It appears that the crowdsourced model can offer some additional richness, thanks to the role played by social networking tools, though social networking that works well for education is still in development. Perhaps new approaches here will help understand the various styles of commitment that manifest schematically in the "long tail" phenomenon that fuels crowdsourcing.

We expect that the role-based style of analysis we employed throughout this chapter, and the idea of paragogy, introduced above, can be applied fruitfully in both offline and online contexts. We look forward to developing these techniques further in our research, teaching, and development work, and invite the OER community at large to use and improve them (as always!).

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KEY TERMS AND DEFINITIONS

Andragogy: Andragogy refers to a learning strategy focused on engaging and motivating adult learners. Andragogy makes the following assumptions about learning design: (i) adults need to know why they need to learn something, (ii) adults need to learn experientially, (iii) adults approach learning as problem-solving, and (iv) adults learn best when the topic is of immediate value (Knowles, 1968, 1980).

Crowdsourcing Education: Crowdsourcing is commonly known as the process of assimilating many small contributions into resources of high quality. Crowdsourcing has emerged as a vital aspect of education on the web, as it promotes the openness and reusability of online educational resources contributed by communities of learners and educators.

Heutagogy: Heutagogy is a theory of self-determined and self-directed learning (Hase & Kenyon, 2000). Heutagogy builds on humanistic theories described in the 1950s and adapts them to the needs of today's learners, particularly targeting the development of individual capability.

Online Community: An online community is a community the members of which use online tools and services in order to engage into social interactions. These tools and services vary from instant messaging (IM) tools and forums to social networks. The members of these communities normally share common interests and goals and use the web in order to communicate with their peers, participate into discussions, exchange ideas, and work collaboratively towards a common goal.

Paragogy: Paragogy is a theory of peer-based learning, built on top of the following principles: (i) context is a decentered center, (ii) meta-learning is a font of knowledge, (iii) peers are equals, but different, (iv) learning is distributed and nonlinear, and (v) realize the dream, then wake up! (Corneli & Danoff, 2011).

Peer-Based Learning: Peer-based learning is driven by peer-mentoring instead of a central mentoring authority. Learners are mentoring each other and engage into a collaborative learning journey. A peer-based course functions similarly to a book club, whose members take turns into recommending books that are studied by the group, followed by an exchange of reviews and opinions.

SECI Model: SECI stands for Socialisation, Externalisation, Combination, and Internalisation. These are the 4 phases of knowledge engineering according to (Nonaka et al., 2000, Nonaka et al., 2003). More specifically, Nonaka and Toyama suggest that knowledge is created as people interact in a shared context, through a process that can be broken up into repeated phases. The SECI model takes into account the range of different behaviours and modes of interaction, involving activities that are both individual and collective, and forms of engagement that are embodied or virtual.

ENDNOTES

1 http://p2pu.org

2 http://planetmath.org

3 http://cnx.org/

4 http://ocw.mit.edu/index.htm

5 http://blog.cnx.org/

6 Although it doesn't exist yet, we can imagine an ongoing hypertext-based discussion of the classic public domain texts that are available on Project Gutenberg (http://gutenberg.org). Such discussions could take place in an attached layer of annotations, and would be "modular" in roughly the same way a library or a university is modular. Such annotations could subsequently be refactored into more integrated works of literary analysis.

7 http://p2pu.org/about

8 http://www.shuttleworthfoundation.org/projects/p2pu/

9 http://groups.google.com/group/diy-math

10 http://en.wikiversity.org/wiki/User:Arided/ImplementingParagogy

11 http://planetmath.org/?op=about

12 See http://bit.ly/polymath-intro.

13 http://wiki.p2pu.org/w/page/12427267/accreditation

14 http://www.open.ac.uk/openlearn/