Semantic Adaptivity and Social Networking in Personal Learning Environments

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Introduction. Perusing the literature, one may quickly discover how many dimensions are relevant to personalized learning. Here is in incomplete list, that illustrates the richness and complexity of this area:

Stakeholders: students, instructors, educational institutions, content providers, technology providers, accreditation bodies [1]

Learning modes: asynchronous or synchronous, co-located or distributed, individual or collaborative, electronic-only or blended [1]

Fundamental needs: subsistence, protection, affection, understanding, participation, leisure, creation, identity, freedom [2]

Knowledge elements: concepts, topics, objectives, outcomes [3]

General features of learners: knowledge, interests, background, goals, traits [3]

Cognitive styles: field-dependent or independent, impulsive or reflective, conceptual or inferential, thematic or relational, holist or serialist [3]

Learning styles: modeled many different ways, cf. for example Felder [4], cited in [3]

Learning skills: self-discipline, ability to work alone, good time management, independence, readiness, the ability to plan [5]

Emotional states: joy/distress, pride/shame, admiration/reproach, etc. [6], cited in [3]

Observable variables: hints asked per question, time taken for each attempt, average time between problems, etc. [3]

Model type: Overlayed, layered, Bayesian network, concept map, etc.

In the face of this complexity, I suggest we begin by looking at something very simple: the link "ACB". This semantic link or triple is equivalent to the labeled arrow C running from A to B in a "concept map" or "bubble diagram", except that C is a cell as well as an arrow, and "ACB" is a structural unit. (RDF triples by any other name; see Section 2.2 of [8].)

(1) When we model this way, we quickly begin to see more than a one layer of annotations; the link is our gateway into the rhizomic world ([9], [10]) of semantic hypertext [11].

(2) In particular, we see, or begin to see, *byproducts of processes*, and *externalities of transactions*.

Discussion. For example, we quickly gain a sense of the global consequences of a simple act in the following diagram:

$$\text{(the eggplant in Mexico} \xrightarrow{\text{tranported by truck}} \text{the eggplant in Massachusetts)} \xrightarrow{\text{produces}} \text{smog.}$$

Or, in an example related to education, according to [7]:

$$\text{(Given the problem of finding the average of three things} \xrightarrow{\text{writing } \frac{(\#\#\#)}{3}} \text{the answer)}$$
$$\xrightarrow{\text{subliminally reenforces}} \text{good use of parentheses and sums in general.}$$

By developing a view of systems and processes comprised of links, products, and so forth ("lightweight" cybernetics, in the spirit of [12]), we begin to be able to study *resource use* in a intersubjectively meaningful way.

We can expose both subjective and intersubjective meanings by putting semantic models and modeling tools in the hands of all users (not just experts). The close similarity between semantic networks and conceptual maps indicates that many of the same intuitive-use features, including features supporting self-directed learning [5], will be directly helpful to learners who are navigating complex resource arrangements. The job of interpreting and adapting to user behavior is very different if input data contains rich semantics (no matter how sloppy), not just one-layer tags to which semantics are supplied later (as in [13]). When we consider the difficulties and limitations in uptake of the semantic web, it seems that sloppiness and informality may be necessary, at first, with precision only coming later.[1]

We want users to be involved with resources drawn from many systems; this suggests that we cannot proceed by building "another insert-name-of-your-favorite-Web-2.0-platform" and insisting everyone users switch from *their* favorite platform to ours. Instead, we would ideally find ways to support everyone's favorite systems transparently in our platform. Silos are inefficient.[2] That said, we must find ways work around the inefficiencies.

Personalization in learning should should capture value and reduce waste and frustration. Sometimes the extra value falls to society as a whole: Recaptcha is a popular web service that exemplifies the idea of getting extra value from routine labor [15]. Sometimes gains will go directly to the student, in terms of time saved, skills gained, or an enhanced sense of meaning. By connecting learning needs and relevant engagement opportunities, we may realistically hope for widely accruing benefits – this is the vision behind student involvement with "real-world problems" in the liberal arts (see e.g. [16]) or sciences (see e.g. [17]).

The key theme in this proposal is that *all* learning takes place in the real world. I claim that understanding the semantics of different modes of learner engagement, and the associated products, externalities, and arbitrage opportunities, is *the* research engine that drives useful, effective, personalization.

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[1] "Tags are easy to create, as users are free to use any word or phrase they please, without restrictions. This simple and highly usable mechanism has caused Social Web applications to be very popular with users. The formal metadata representation employed by the Semantic Web, on the other hand, makes it far more difficult to create annotations. Although semantic metadata has enormous potential, its limitations in terms of usability are proving a significant barrier which discourages users and prevents the technology from becoming more widely established." [14]

[2] "Social networking sites (e.g. MySpace and Facebook) support the creation of a social graph describing relationships between users of such systems. However, such sites maintain their own social graph representations and these are not usually transferable between sites, i.e. if a user moves to a different site they may to describe all of their friends again to recreate their social graph." [14]

Agenda. *(Phase I.)* I propose to begin with a thorough resource-use analysis in three domains:

(1) personalized learning environments in general – greatly expanding the survey above and adding semantic connections between the relevant dimensions;

(2) the major target domain OpenLearn[3]; and

(3) PlanetMath.org[4], a non-profit community-based mathematics website, on whose board of directors I serve.

Over the past several years I have developed an open source triples-based software system, Arxana, that stands ready to facilitate this work [18]. Studying Domain *(1)* will expose other approaches, and a comparison of approaches should help us understand how to extend or modify the triples-based approach to best address the issues in personalized learning. Domains *(2)* and *(3)* possess very different user communities and inherent semantics, and a comparative study will give us a stereoscopic view into the social/semantic web.

(Phase II.) I propose to continue by deploying Arxana in a demo form that is accessible to the populations in Domains *(1)*, *(2)*, and *(3)*. I want to emphasize using semantic networks as tools for building learning objects, curricula suitable for self-directed study, and personalized learning plans. System prototyping in Domain *(3)* will hopefully proceed in collaboration with Ross Moore[5], Frank Quinn[6], and the Noösphere development team[7], to develop tools that will transform PlanetMath from being a reference resource, into a tool that students can actually use to learn mathematics: our degree of success should be measured by evaluating student learning. System prototyping in Domain *(2)* will proceed in concert with the ROLE Project[8] and will follow evaluation criteria specified by that project[9]. The resource-use analysis in Domain *(1)* will also relate to, and contextualize, the various deliverables of the ROLE Project, and the system prototype in this area should help developers and designers working in this area see their work in a broad social context.

(Phase III.) I propose to conclude the project by integrating my findings into a web service-supported browser plug-in, or other suitable tool, that works transparently with other web platforms, so that I can *(a)* make the data and structures I've collected, created, or curated, available to the public; *(b)* facilitate novel use by educators and others; and *(c)* continue to gather new data and structures in a commons-based peer produced fashion [19]. One central objective for this phase is to develop a general referral service ("if you like this you might like that", or "if you think you like this, you might like that *better*"). Note that this is not "another web annotation tool"[10] – it is a browser and editor for the social semantic web. I plan to evaluate this tool by gathering use-statistics and finding a way to measure the value gained by using referrals.

[3]OpenLearn, http://openlearn.open.ac.uk/
[4]PlanetMath.org: Math for the people, by the people, http://planetmath.org
[5]Towards tagged PDF, http://www.tug.org/tug2009/abstracts/moore.txt
[6]The EduTeX Wiki, http://edutex-wiki.tug.org/wiki/index.php?title=Main_Page
[7]Noösphere (diaeresis optional), http://code.google.com/p/noosphere/
[8]Responsive Open Learning Environments (ROLE), http://www.role-project.eu
[9]Deliverable M48, http://www.role-project.eu/Deliverables
[10]Web annotation, in Wikipedia, http://en.wikipedia.org/wiki/Web_annotation

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