Crowdsourcing Higher Education: A Design Proposal for Distributed Learning

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Abstract

Higher education faces dual challenges to reduce expenditures and improve learning outcomes through faster graduation rates. These challenges can be met through a personalized learning system (PLS) that employs techniques from previous successful instructional designs. Based on social learning theory, the PLS combines a dynamic menu that tracks individual topic mastery with a social communication interface that connects knowledge-seekers with knowledge-providers. The crowdsourced generation of content from these connections is stored in a library for availability when live mentors are unavailable. The quality of the generated stored content is vetted against subsequent performance by knowledge-seekers whose performance creates recognition for knowledge-providers in a game-like public rating scheme.

Keywords: crowdsourcing, social, personalized, intrinsic motivation

The Problem of Efficiency and Effectiveness

Higher education faces a dilemma: institutions are being expected to simultaneously reduce expenditures and improve learning outcomes through faster graduation rates. In some states such as Texas, legal requirements now stipulate demonstrable improvement in student graduation rates (Texas Higher Education Coordinating Board, September, 2010). The quandary is not unique to Texas, although the problem is more severe in Texas than in most states: Texas ranks 35th in the nation for graduation within six years (*Austin American-Statesman*, 2010, July 13). Nationally, rates for graduation within six years have improved only marginally from 52% to 55% over the last decade (NCHEMS, 2011), while rates for graduation within four years from public universities has declined to 29% in 2008, the latest year for which data is available (Horn, 2010). Retention (or continuation) between first- and second-year new students offers another measure of effectiveness. Between 2004 and 2010, the third and fourth national surveys, ACT and the National Center for Higher Education Management Systems (Habley & McClanahan, 2004; Habley, *et.al*, 2010) found that the overall retention rate was unchanged over six years at approximately 67%. With longer graduation times and stagnant retention rates, little wonder that the American public views higher education progress as minimal.

At the same time, the cost of public higher education has risen even faster than the cost of healthcare (Langfitt, 1990). Increased costs have primarily impacted the pocketbooks of students as public appropriations for universities over the last decade have declined an average of 5.6% annually adjusted for inflation (Southern Regional Education Board, 2010). Private universities are not significantly better off. Although the average tuition and fee increase at private institutions over the last decade was only 3.0% per year compared with 5.6% per year at public four-year schools (Baum & Ma, 2010), the number of students with loans at private institutions rose 50% from 1993 to 2008 (Baum & Ma, 2010). Average student loan debt increased 24% from 2004 to 2008 according to The Project on Student Debt (2010), and the average debt for graduates of private universities is now more than $27,000 according to Lataif (2011) who calls this trend "unsustainable." In 2010, student loan debt exceeded credit card debt for the first time to become the largest financial obligation for Americans (Lewin, 2011). Little wonder that the American public views higher education as increasingly unaffordable. The combination of rising costs and perceived low performance is reflected in the public's lack of confidence in higher education to deliver a worthwhile service (Texas Public Policy Foundation, December 6, 2010).

To meet the twin demands of effectiveness and efficiency, the academy must adopt a revolutionary approach to instruction which integrates contemporary learning theories with recent research from information science. While the path of instructional technology is littered with the unfulfilled promises of all-encompassing answers, a possible solution is emerging. The growing availability of low-cost computer networks, capable of linking novices and experts in social and contextual environments, reduces the inherent friction of production and elaboration in higher education. Learners no longer need travel to Cambridge to take a media literacy course from Henry Jenkins; they can watch his lecture on an iPhone™ or friend him on Facebook™ and chat about the utility of social networks. Using networks for distributed learning can solve the efficiency challenge if the academy can embed that learning in effective instruction.

A Proposed Solution

If networked communities can increase efficiency, learning networks that provide effective outcomes offer a solution to the dilemma faced by higher education. Retention research suggests a potential appropriate community: a Lumina study (Lesik, 2004) found that successful developmental students were four times more likely to graduate, a significant factor also identified by Fike (2004). Harvey & Drew (2006) and Crossling & Heagney (2008) identified student-centered experiences and formative assessments as two key predictors of graduation as well as continuation rates. A personalized mastery-based social learning environment may allow students to increase course completion rates.

Effective instruction requires constant adjustment to the learner, reinforcing mastered concepts and holding out new concepts that are barely able to be mastered by the learner at that point in his or her concept knowledge trajectory. Computers can constantly evaluate and adjust to inputs in an efficient manner, providing personalized instruction. Computers can also track performance at a granular level and match learners with experts on the basis of fine-grained competencies for the purpose of targeted mentoring. Embedding these metrics within a networked environment facilitates the computer's information management capabilities across multiple characteristics of learning interactions and within a computer-mediated socialized network.

However, humans can better interpret a lack of understanding of the intermediate steps in a problem-solving process, and humans can offer complementary explanations easily adjusted based on feedback. Digital capture of these explanations can be archived for use by other students, and the quality of those digital artifacts can be verified by the performance of the student consumers, resulting in a collection of diverse and proven solutions.

Proposal: Integrating computerized management for individualized tracking with system-allocated human guidance for problem interpretation via online transactions among socialized learners can provide an effective and efficient instructional environment.

Crowdsourcing Instruction

Crowdsourcing views humans as processing units which can be integrated with computer processors to draw on the unique strengths of each (Alonso, 2011). Crowdsourcing is not a group of people performing a task typically performed by an individual, but rather an approach that leverages the individual strengths of human and machine processing. For example, image recognition is a human strength. Humans can recognize the now familiar reCaptcha web security words shown in Figure 1 faster and more accurately than the computer that displays the text image. However, that same computer can sort the reCaptcha image-word pairs faster and more accurately than the human coders. The allocation of human guidance in micro-work systems such as Amazon Turk relies on crowdsourcing.

Computers excel at *manipulating* large data sets, while humans excel at *interpreting* data. Brabham (2008) argues that crowdsourcing offers a solution to complex problems that require both types of computing: human and machine, interpreting and manipulating. Because of the concealed nature of individual cognition, the construction of effective educational experiences requires the intervention of humans; however, efficiency may also be realized if appropriate machine computing provides support for data management and resource allocation. Surowiecki (2004) maintains that crowdsourcing "wisdom" requires independent, decentralized answers with cognitive variety, properties that are characteristic of a collection of solutions created and rated by individuals. As a result, this design proposal employs crowdsourcing as a mechanism to match knowledge-providers with knowledge-seekers within a defined group and to also provide seekers with a diverse solution set through the digital capture of provider-seeker interactions.

Figure 1. *reCAPTCHA™. Automated system to combine human and machine strengths in image-to-text processing.*

A Design Scenario

Combining a crowdsourced knowledge-mapping system with solution capture builds a library of solutions for future use. Instruction at the individual level that identifies topical areas requiring assistance can offer both previously captured solutions and synchronous human explication. Consider the following scenario:

> *It's 10 pm, and Will is working on his assigned Chemistry 101 homework. He logs into his personal learning system (PLS), and the Chemistry course menu shows he left off his last session at "Balancing Equations" so he decides to tackle that topic this evening. The PLS assigns random problems from the "balancing" topic, and Will works a couple of problems correctly, then misses a couple. After working on the problem set and failing to correctly answer four consecutive questions, the PLS soon offers him the choice of watching a video or talking with another student. Will watches the video, but when he tries the problem set again, he is still unable to correctly answer four problems in a row and decides he needs to talk with someone. The system matches him randomly with Miguel, another Chemistry 101 student who is online and who has already mastered the topic. The system launches a semi-private (first names only) voice-enabled whiteboard with the last problem Will missed on the screen. Miguel talks Will through the problem and offers hints on how he (Miguel) approaches the "balancing" topic, in this case, by starting with the atom with the largest coefficient. The whiteboard session is limited to five minutes, so neither person dawdles; at the same time, because Will can complete a brief survey at the end of the session about Miguel's helpfulness, Miguel tries to be friendly and informal. When the whiteboard session is over, Will returns to the "Balancing Equations" topic. If he can now correctly answer four problems in a row, Will's introductory level for that topic is marked complete, and the PLS introduces a more difficult set of "balancing" problems selected by his team of instructors who designed the assessments. If Miguel's solution engenders Will's success, Miguel is credited with a point on the Chemistry leader board. If Miguel accumulates enough points, he may be offered a teaching assistant job next year. Miguel's and Will's video session was recorded and added to the library of videos for the "balancing" topic and awarded a point if it was successful. Over time, if other students are similarly successful with the "balancing" topic after watching Miguel's and Will's video, the session will be publicly recognized as an effective instructional segment for the topic and will rise to the top of recommended content objects for that topic.*

The creation of effective instructional media is expensive. Crowdsourcing the learner-mentor interaction provides a necessary human interpretation and at the same time creates instructional segments which are vetted for quality by measuring segment success with both the immediate learner and future learners.

Theoretical Underpinnings

These interactions, as well as the personalized learning portal envisioned, draw on communication and learning theories that have common roots in social cognition research. Early studies in computer-mediated communication (CMC) by Sproull & Kiesler (1986) led to concerns over deindividuation, exacerbated by the innate anonymity of mechanical intermediaries (telephone, computer) in interpersonal communication. However, as the increasing ubiquity of powerful devices with broadband access enabled mediated socialization, these concerns have been replaced with theories for identifying intrinsically motivating activities and for understanding learning transactions.

Computer-mediated Communication: Group Identification Overcomes Lack of Cues

Using computers as a message intermediary draws on extensive research in computer-mediated communication (CMC). The two prevalent theories view communicative transactions through the lens of either Social Information Processing (SIP) or the Social Identity model of Deindividuation Effects (SIDE).

Walther (1996) proposed that CMC filters out cues and temporally retards communication; however, the expectation of future interaction is processed as socializing information that ultimately enables deeper interpersonal development. On the other hand, SIDE proposed that CMC within groups can actually enhance shared social identity: the process of depersonalization is accentuated, and cognitive efforts to perceive groups as entities are amplified (Postmes, *et.al.*, 1998). While the two models differ in how the effect of CMC anonymity on behavior is explained, the theories converge on the important role of social groups on identity formation and communicative behavior in CMC. The crowdsourced PLS works within the environment of a social group—the class—to reduce deindividuation effects.

Social Constructivism: Learning is Social (Networking)

Vygotsky determined that learning occurs primarily through social mechanisms. Wertsch & Sohmer (1995) trace two additional themes from Vygotsky's work: the requirement of a coach (or "more knowledgeable other") and the identification that learning occurs in the "zone of proximal development," the region between the learner's ability to perform a task under the guidance of a coach and the learner's ability to solve the problem independently. Bandura (1977) introduced the importance of incentive and identified motivation as one of four factors (along with attention, retention, and reproduction) for knowledge modeling in social learning. Lave & Wenger (1990) added the role of environment by showing that learning occurs in contextual situations, evolving from "legitimate peripheral participation" to full participation in an authentic community of practice. John Seely Brown (1989) extended situated learning to emphasize the role of cognitive apprenticeship. The crowdsourced PLS is based on social learning experiences embedded in an authentic "just in time" community of learning: the online mentor provides apprenticeship, and the dynamic menu continues to increase the depth of the topic to the level needed by each student individually (for example, an Engineering major needs more depth in Calculus than a Journalism major).

Flow: Intrinsic Motivation Compels Time on Task

Csíkszentmihályi (1990) developed the concept of an immersive state of consciousness he described as, "flow." Csíkszentmihályi identified the characteristics and conditions which produce a flow state in multiple activities:

- Both expectations and rules are discernible and provide direction and structure.
- Direct and immediate feedback (both success and failure) is apparent so that individuals may negotiate changing demands and adjust performance to maintain the flow state.
- Goals are attainable and aligned with personal abilities at the specific moment; the challenge level of the task and the individual's skill are balanced. The activity delivers a sense of personal control and provides intrinsic reward.

Flow typically has been associated with leisure activities because of their intrinsic reward structure, fun. In particular, game designers such as Salen & Zimmerman (2003) build flow conditions to create absorbing interactive experiences. The problem assignment mechanism in the crowdsourced PLS relies on the same clear rules and continually adjusts the difficulty level to match the learner's current understanding, offering both stored and live instruction as requested. These game-like features provide learner motivation which increases time on task, a key function of improved learning (Chickering & Gamson, 1987). Success provides continuing motivation via the self-efficacy of individual achievement.

Social capital in academic groups is based on session contribution to subsequent (mentored) students' successes. The contributions are recognized via leader board badges and are based on intrinsic motivation factors identified by Pink (2009). In addition, the community welfare appeal offers altruistic reasons for mentor participation, a factor that Rogstadiusa (2011) found increased quality in crowdsourced mechanisms.

Transactional Distance: Networked Learning Demands Student-To-Student Interaction

Moore's (1997) transactional distance model views non-proximate learning in CMC as a series of interactions between a learner and three entities: instructors, content, and other students. This perspective enables the design of instruction to focus on the triplet of learner-to-instructor, learner-to-content, and learner-to-other-students. The crowdsourced PLS offers stored content sessions and student-to-student live mentoring under the design of the faculty member who created the assessment scheme.

Theoretical Fusion

These four theoretical approaches find a common home in a distributed learning network. An online system that combines the motivation of personal goal achievement with the socialization aspects of peer mentoring offers an effective solution. The environmental focus on a defined group of individuals, students enrolled in a course whose members anticipate future interaction in the classroom, reduces anonymity in online mentoring. The integration of game mechanics increases the use of the system through intrinsic motivators. The management of personalized learning and the real-world application of social learning transactions provide efficiency.

Proven Forerunners: Successful Design Implementations

Instructional design proceeds from theory, and the growth of design techniques that rely on learning networks has accelerated in recent years with the growth of broadband Internet access. Distributed work teams and community evaluation and guidance have emerged as accepted methods for solving problems over geographical distances (Resta & Laferrière, 2007). Public productions offered as open content build online reputations and become invaluable knowledge stores. The situated challenges of online multiplayer games have spawned a multi-billion dollar industry. The common thread in these applications is their social nature, and the implementation of social learning techniques has spawned several successful instructional designs.

Collaborative Projects

The application of CMC research on the importance of group identity has found expression in computer-supported collaborative learning (CSCL). Early work in computer-assisted instruction (CAI) demonstrated the efficacy of self-paced and personalized approaches, but the addition of human communication can expand discipline-specific application beyond skill development to analytical levels. Building on Internet-based communication tools, collaborative projects such as wikis typically involve student teams working together on projects. These knowledge-building communities expose students to diverse opinions where meaning is constructed through negotiation. The non-computer implementation of this approach is the classroom-based study group. The addition of network mediation enables spatial independence for students who may collaborate synchronously from dispersed locations and temporal independence for students who may cooperate asynchronously. Thus, CSCL increases the possibility of communicative activities and participation through ubiquitous access. The crowdsourced mentoring is a collaborative activity in which the mentor earns recognition and the learner succeeds. This team approach reduces faculty member workload by focusing faculty-to-student interactions on assessment.

Supplemental Instruction (SI)

Treisman (1983) investigated techniques for improving the performance of black students in Calculus at the University of California at Berkeley; his findings on the effectiveness of peer study groups presaged the development of supplemental instruction (SI) which was codified by Deanna Martin (Burmeister, 1996) at the University of Missouri at Kansas City (UMKC). Arendale (1994) identified key characteristics of the SI model, one of which was tying the design to a specific course as an archetypal rather than remedial practice; mentors participate in the class, and a high degree of student-to-student interaction occurs in SI groups.

Arendale (1996) analyzed data from the UMKC campus for 16 years: controlling for motivation, race, previous academic achievement, and academic discipline, he found that:

- Grades among SI students on a four-point scale averaged 2.682 compared with 2.292 for non-SI students in the same courses.
- Attrition (percentage of W, D and F grades) among SI students averaged 18.213% compared with 32.169% among non-SI students in the same courses.

This longitudinal study also notes that the University of Texas compared SI with non-SI discussion sessions to control for time on task and found that SI student grade performance and retention was still significantly higher than non-SI student grade performance and retention. The crowdsourced PLS is an online implementation of supplemental instruction, although the PLS mentors are paid in social recognition instead of cash. SI requires the process to be viewed as additive, not remedial, which is accomplished in the crowdsourced mentoring through its optional but omnipresent offering.

Open Educational Resources (OER)

Exemplified by MIT's Open Courseware Project, open educational resources provide course materials for direct access and reuse. Learners are encouraged to utilize and in some cases, modify and share improvements in a content collaboration similar to Wikipedia. Websites such as Sophia.org, SalKhan.org, and Merlot.org offer non- or inter-institutional collections of learning objects tagged with expert and student evaluations. Instructional variety serves diverse learning styles because not every student can learn the same concept through the same homogeneous content. Extending the open content model, the University of Manitoba offered an open online course in 2008 which enrolled more than 2,300 students (Fini, 2009). The PLS solutions library functions as an open resource, at least for that class at a specific institution, with diverse content which can be directed to students on the basis of demographic data, learning patterns, and other performance metrics captured and indexed by the crowdsourced PLS.

Public Content

Jenkins (2006) argues that students are digital residents who live in a participatory age. Participation in the content construction aspect of learning environments is often characterized by the use of blogs or discussion boards that ask student to analyze and summarize core readings in a discipline and encourage (or require) peer responses to those posts. The pedagogical affordance of analysis by each student reduces faculty member workload by shifting the responsibility for knowledge acquisition to each individual learner. The formalization of blogs and other student-created content is realized in the advent of student portfolios. Course assignments in a public venue are available to an articulated audience in a durable format; access to this venue can enable collaboration and peer assessment. The stored and published output of crowdsourced mentoring sessions produces public content. The value of that content is determined and publically recognized with a game-like leader board. Points are awarded for evidence-based results (when users of the content solve problems) as well as for subjective user-based surveys.

Peer Assessment

Peer assessment in and of itself reduces faculty member workload and increases student analytical prowess. Implementations of peer assessment system such as OASYS (Ward, 2004) and WebPA (Loddington, *et.al.*, 2009) use statistical techniques to adjust weights based on individual reliability ratios. Quality control mechanisms in the form of peer rating analysis that contribute to mentor grades also reduce gaming. Davidson (2011) showed that crowd-sourced grading can provide an effective assessment of student outcomes. Rubrics tied to goals produce more precise assessment evaluations by both peers and experts. The feedback mechanism to recognize successful solution interactions from mentoring provides implicit peer assessment. Viewing the crowdsourced PLS as a social group transforms this implicit peer assessment into a community-based evaluation.

Problem-Based Learning (PBL)

While acknowledging the necessity of learning basic facts, social constructivism approaches learning from the perspective of how those facts will be utilized as building blocks within the individual learner's cognitive domain. This approach is exemplified in PBL: students are situated in a real-world environment which provides intrinsic motivation through both the authentic context and the socialization component. PBL relies on dyadic/group communication to activate prior knowledge which is then elaborated and restructured. The crowdsourced PLS situates students directly in the learning environment at the moment of need and relies on human communication to interpret complex problems. Faculty workload is reduced through the engagement of external mentors (in real-time or as a content resource from the stored sessions) who fill the role traditionally assigned to discussion leaders. Situating these communications in virtual environments, whether fictional (Liu, 2006) or real (Doering, Scharber, Miller, & Veletsianos, 2009), provides intrinsic motivation for learners to remain personally engaged.

Serious Games

Shaffer (2006) delineated a class of serious games for learning purposes which he termed “epistemic games,” characterized by asking students to:

- Develop schematic knowledge by combining facts (declarative knowledge) and problem-solving strategies (procedural knowledge) to solve problems
- Develop symbolic knowledge in solving one problem which can be used to solve other analogous problems

- Develop social knowledge by solving problems, discussing the solution with the community, and repeating this iterative cycle until the process is internalized

Epistemic games combine PBL authenticity with the intrinsic motivation of fun. Scaffolded instruction and the associated concept of fading (withdrawing support as skill increases) are exemplified by levels of achievement within the game. The crowdsourced PLS incorporates game mechanics in the use of topic levels, public recognition of accomplishment, and a social community that implicitly votes on acceptance through successful use of the created artifacts. User control is afforded by the learner's ability to select stored or live mentoring content.

Design Integration

However, none of these successful implementations fully integrate the multiple applicable theoretical views, and thus each implementation only partially realizes both effective outcomes and cost-efficiency. Table 1 summarizes the learner advantages and the system disadvantages of each approach. At the same time, these design implementations of the four theoretical bases (computer-mediated communication, social cognitivism, flow, and transactional distance) each contribute a significant design element:

- Collaborative projects– active participation in mentoring sessions
- Supplemental Instruction (SI) – mentoring sessions which are integrated in the instruction
- Open Educational Resources (OER) – content stored under the Creative Commons BY-SA license extends the mentoring audience to external populations defined by the institution
- Public content – stored videos offered through personalized menus
- Peer assessment – effectiveness quality ratings derived from subsequent mastery; social quality determined from a brief post-session survey
- Problem-Based Learning (PBL) – situated directly in course as the assignment and assessment engine
- Serious games – level design in problem menu with immediate feedback; intrinsic motivation with public leader board; extrinsic motivation with grades and potential future employment for successful mentors (in teaching assistant positions)

Design Functions

Gamification

The online mentoring sessions are founded on supplemental instruction techniques. However, game mechanics contribute significantly to the dynamic menu design and the concept of public recognition for mentors. Each student builds a personalized task menu of needed knowledge by working through faculty-generated course objectives and assessments. The menu is constantly updated as knowledge is acquired and provides a self-actualizing progress report as shown in Figure 2. Discrete topics identified as "in progress" are taught via live or stored mentoring sessions.

Social interaction

Human interactions in the form of stored mentoring sessions provide an anthology of worked examples and address concerns regarding the high cognitive load inherent in PBL (Kirschner *et.al.* 2006). Stored sessions carry success ratios based on subsequent performance by students using those sessions, and they form a pattern library with increased payload value based on iterative and covert evaluation. The stored sessions as shown in Figure 3 offer the increased knowledge density of spatial memory over declarative and procedural memory (Gagné, *et.al.*, 1993). In order to accommodate students with visual impairments, the voice chat audio stream from mentoring sessions will be automatically captioned to provide a text alternative.

Table 1. *Instructional Design Approaches*

Approach	**Advantages for learners**	**System disadvantages**
Collaborative projects	Socialization within group	Potential for no individual accountability
Supplemental Instruction (SI)	Socialization within group Content placed in immediate problem context	User-initiated (not embedded)
Open Educational Resources (OER)	Socialization within group User control	Lack of personal direction
Public content	Opportunity for reflection Motivation from participation	Absence of assessment and feedback
Peer assessment	Motivation from participation	Possible system manipulation
Problem-Based Learning (PBL)	Motivation from participation Socialization within group Content placed in immediate problem context	Requires external experts
Serious games	Motivation from participation Socialization within group Content placed in immediate problem context Intrinsic motivation for learners and mentors	Expensive to develop

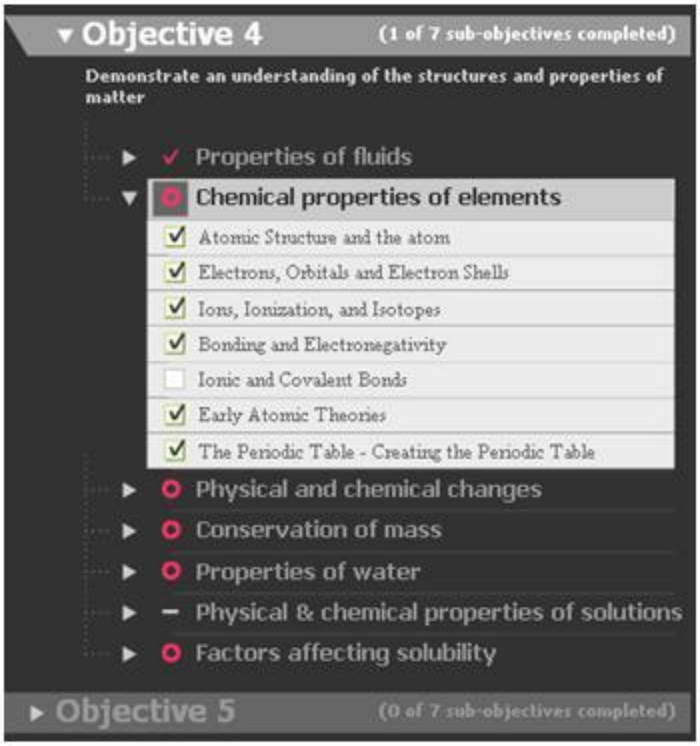

Figure 2. Task menu The dynamic and personalized menu shows mastered and un-mastered topics for each student: some are self-selected for study within a learning objective, while others may be locked until acquisition of prior requisite knowledge has been demonstrated.

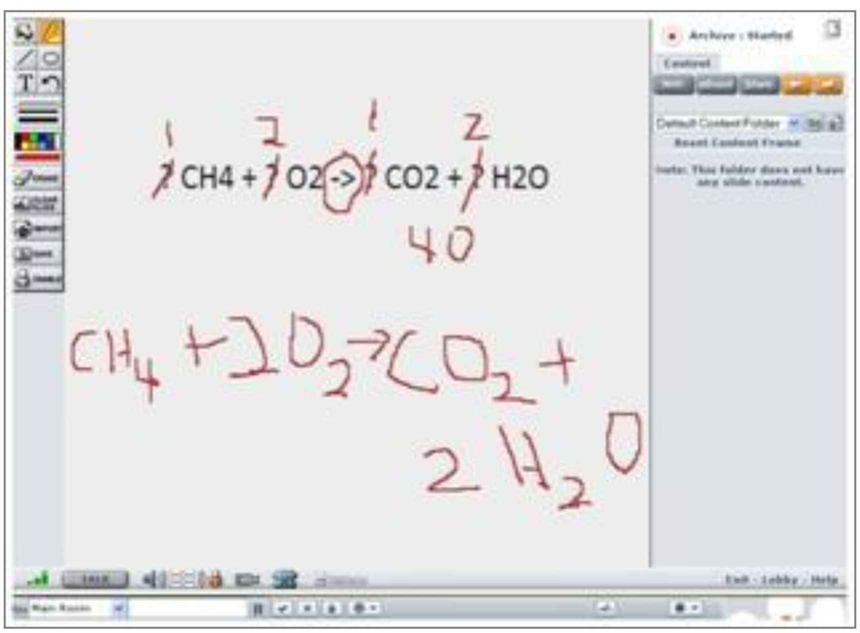

Figure 3. Mentoring whiteboard The whiteboard shows a mentor's written explanation drawn on a chemical equation provided by the PLS as an image. The mentoring session is accompanied by voice chat capabilities for both participants. Note (upper right) that the session is archived as an MP4 video for incorporation into the stored library if subsequent student use demonstrates the video's effectiveness.

Typical instructional sequence

Table 2 traces a linear sequence of events in the crowdsourced PLS, although many interactions will be iterative.

Table 2. *Human/Computer interaction flow*

Step	Student	Computer	Mentor
1) Problem generation	Logs into system and selects topic	Generates algorithmic problem based on either previous stopping point or target skill level for topic	
2a) Answer evaluation	Demonstrates topic mastery	Judges answer: if all are correct after 4 consecutive solutions, return to Step 1) and assign more difficult problem in same topic	
2b) Answer evaluation	Is unable to demonstrate topic mastery (primed for assistance)	Judges answer: if incorrect, return to Step 1) and assign parallel problem in same topic; if 4 successive cycles have occurred (or >6 cycles total), locate stored pattern solution in library or match with a mentor based on mentor's demonstrated mastery	
3a) Knowledge retrieval	Selects solution from previous stored session (different student-mentor)	Recommends alternative explanations from library of prior proven solutions	
3b) Mentoring session	Interacts with live mentor		Provides one-on-one mentoring in a problem-solution format
3b') Knowledge capture		Captures, tags (with performance metrics and survey results), and stores mentoring session in pattern solution library	
4) Knowledge evaluation		System provides covert feedback on stored session effectiveness based on student results (and later, subsequent student results); generates reputation points for mentor	

Considerations

Noise

Noise is minimized through the reliance on post-session student performance. While this reliance provides external validity to the PLS, the design incorporates additional elements to prevent exploitation and reduce potentially unpleasant interactions.

Exploitation

Student and mentor identities are masked (only first names are used) during the sessions. While physical identities may be recognizable from classroom interactions, and while mentor recognition is public on the leader board, student identities are always private in the PLS. Student-mentor sessions are limited to five minutes, and no images may be introduced other than the problem assigned by the PLS; this design implementation limits off-topic interaction in the live mentoring sessions.

Student-mentor assignments are made through a topic mastery algorithm. To the largest extent possible, these assignments are randomized to prevent collusion and artificial inflation of mentor ratings and stored session performance metrics. The inclusion of a brief exit survey regarding student satisfaction at the end of each session produces data used by the mentor-matching algorithm to avoid matches that create interpersonal conflict.

Mentor Availability

In order to offer user control, students choose between live and stored mentoring sessions. However, this choice presupposes the availability of willing mentors at the moment the student requests assistance, a tenuous assumption that is even more suspect at start-up. Further, until the pattern library is sufficiently robust, even the availability of stored sessions is questionable. As a result, several initial priming implementations may be required:

- Load existing third party content from sources such as MERLOT, the National Repository of Online Courses, and the Sal Khan Academy until a sufficient number of local mentor sessions have been captured.
- Staff the mentor pool with selected T.A.'s to provide coverage until the pool is self-sustaining from the student community.
- Offer asynchronous support using a wiki interface for question collection and knowledge consolidation as an alternative to the immediacy of either live or stored mentor sessions.

Future Considerations

Written Products

While the writing component of many courses may be able to benefit from a common assignment model (such as, "Construct a five-paragraph argumentative essay on the topic of *x*, taking the position of *y*" with the variables *x* and *y* pulled from a database), the judging of answers to those problems requires human evaluation despite advances in computerized discourse assessment. In a writing implementation, crowdsourcing can provide that assessment. Braddock, *et.al.* (1963) found that rubric-based assessment of writing assignments yielded inter-rater reliabilities ranging from .87 to .96. This high level of reliability suggests that peer evaluations of written products can be accurate if accompanied by clear assessment direction.

Non-algorithmic Learning

Not all courses lend themselves to automated problem generation, especially courses beyond the developmental and introductory levels. Non-algorithmic problem sets can substitute crowdsourced assessment in the answer judging step and follow the remainder of the interaction flow diagram (see Appendix I) by offering both live and stored mentoring sessions to implement refinements recommended by the crowdsourced assessment. Cases, adventures, collaborative projects, and other team-based designs are encompassed in the interaction flow diagram by viewing groups of students as a proxy for a single user.

The Generalized Solution Space

The dual challenges of efficiency and effectiveness demand a radical restructuring of the traditional roles in higher education. Faculty members must cede sole responsibility for direct instruction to knowledgeable students in exchange for deeper interaction with individual students. At the same time, faculty members must retain scope and sequence and assessment control. Students must take ownership of their own learning in exchange for multiple modes of engagement in familiar online social venues. At the same time, students must accept communal responsibility and provide mentoring in a *quid pro quo* environment where payment is non-material. Empowered by proven techniques in social learning design and crowdsourcing, these new responsibilities promise more effective and efficient learning outcomes. Unlike previous models that require constant external and expert maintenance, the PLS is an organic system that grows in value with use. We must seize connected wisdom today.

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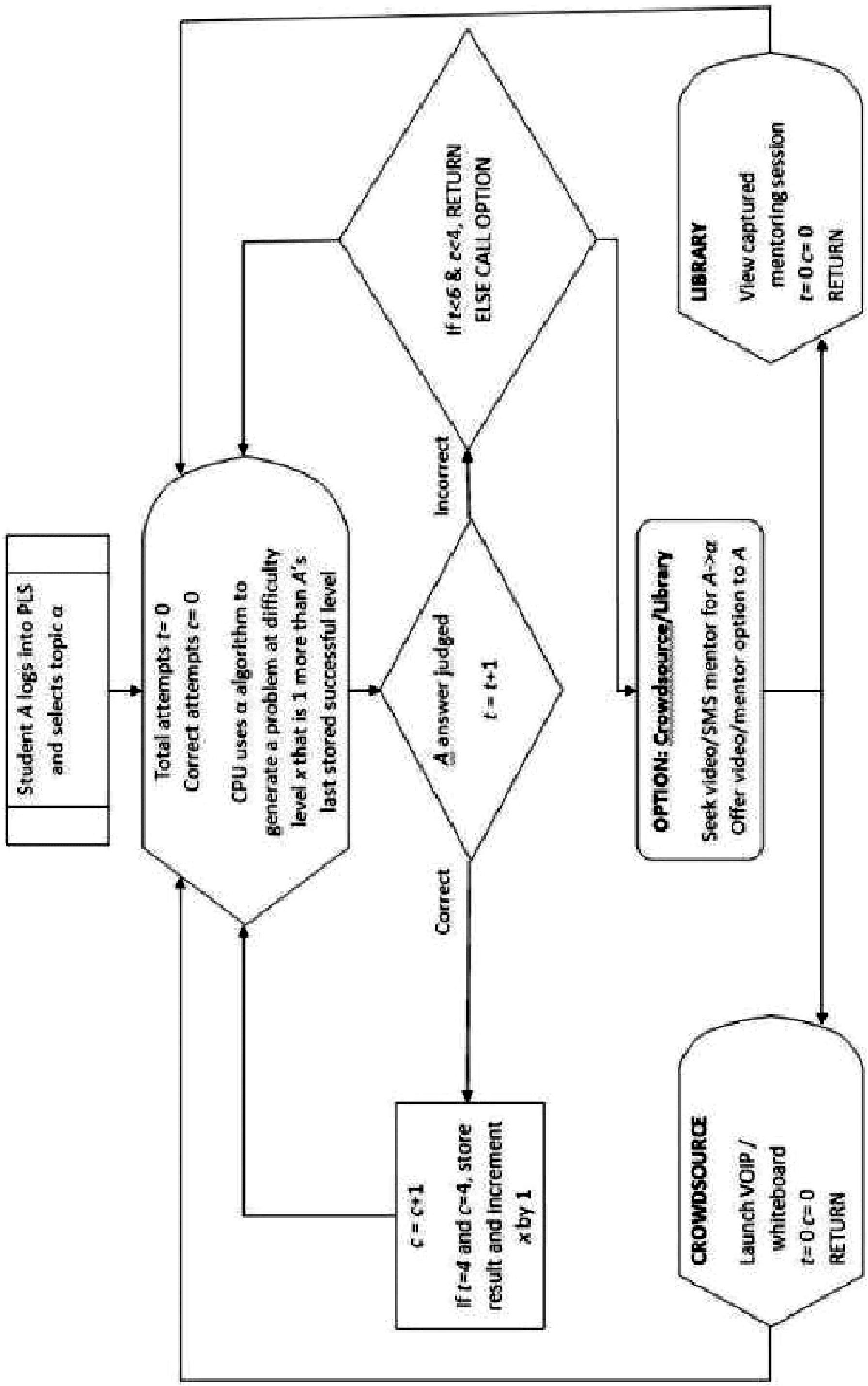
Appendix I: Interaction flow diagram



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