Social Annotation to Enhance Learning and Assessment in Higher Education

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ABSTRACT

Social annotation products make the thinking of learners transparent, visible, and easily accessible for sharing with others, self-reflection, and feedback. This is accomplished by enabling almost any number of users to have threaded discussions linked to selected sections of a page. Three professors share their experiences with the use of a social annotation product, HyLighter, to enhance teaching, learning and assessment activities in three different areas of the college curriculum. One teaches screenplay writing. He describes how he used HyLighter to improve students’ writing and critical review skills. A second teaches online graduate-level courses in pharmaceutical and forensic sciences. He describes the application of HyLighter to help students learn about chemical structures and related analytical principles. A third is a professor of educational psychology. She discusses her use of HyLighter to implement an alternative multiple-choice assessment approach in educational and developmental psychology courses. The chapter concludes with thoughts on the potential of social annotation technology to shift the focus of learning systems from content to be learned to what is going on inside the minds of learners.

Collaborative or social annotation products enable users to have threaded discussions linked to selected sections of a page. This capability is in contrast to wikis which enable easy co-creation and editing of web pages but are limited for purposes of discussion. By making the thinking of learners transparent, visible, and easily accessible for sharing with others, self-reflection, and feedback, social annotation tools have the potential to shift the focus of learning systems from content to be learned to what is going on inside the minds of learners. After a brief description of HyLighter, a browser-based social annotation product developed by HyLighter LLC (see www.hylighter.com), three professors describe their experiences using this
product in their classes followed by concluding comments. Of note, the development of HyLighter is led by two of the co-authors, David G. Lebow and Dale W. Lick and a dedicated team of programmers led by Kamal Muthuswamy.

Description of HyLighter

In the Middle Ages, the manuscript served as a type of low-tech social annotation medium. Scholars used the margins and spaces between lines of manuscripts to engage in dialogue with other readers. The same physical copy of a manuscript was passed around a community, and readers used the margins to correct errors, debate interpretations, and learn from the annotations left behind by previous readers. In a sense, the manuscript was a medium for knowledge-production distributed between readers and writers (Wahlstrom & Scruton, 1997; Wolfe, 2008).

Today, hundreds of systems exist (e.g., Google Sidewiki, Reframe It, and Webnotes) that allow users to annotate web-based or other data via the Web or other Internet protocol. However, despite the proliferation of these products, two problems with annotation interfaces have stood in the way of realizing the potential of social annotation for teaching and learning. Firstly, the margins of the page provide limited space for placement of commentary and extended threaded discussions. As more participants add more annotations, the challenge for the designer is how to keep commentary aligned with targeted text or objects without creating separation between the two and adding cognitive effort for the user. Secondly, as more participants add highlighting and other markup to the primary text or image, the accumulating markup (i.e., highlighting, strikethroughs, and other marks - often with different colors to represent different contributors), may overwrite the document and create a confusing mass of metadata (e.g., as is the case with software programs such as Microsoft Word Track Changes or Acrobat Connect).

HyLighter solves the problems of how to manage accumulating and overlapping markup and limited space for displaying commentary through (a) its color-coding mechanism for “mapping” the intellectual travels of reviewers through a document or source (e.g., HTML, Word, Excel, PowerPoint, PDF, JPEG, and GIF), (b) its capacity to align commentary in the margins with related sections of a page, despite the limited real estate available, and (c)
various methods for organizing, analyzing, and editing input. The approach enables almost any
number of individuals (e.g., an instructor and online class of 30 or more students) to engage in
collaborative conversations tied to specific sections of a source without overwriting the primary
source or cluttering the margin.

Figure 1 shows the unique approach of HyLighter to mapping the distribution of
highlighting (i.e., areas emphasized and commented on by readers) through a document.

![Figure 1. The HyLighter Screen. The browser displays the HyLighter tool bar below the
browser tabs. The screen is split into two panels. The right panel holds the source with various
color-coded sections. The left panel shows comments and related information submitted by
contributors.](image)

An area highlighted by you (the logged in user) but not by anyone else appears in yellow;
areas not highlighted by you, but marked by one or more contributors, appear in shades of
blue (the darker the shade, the more overlapping interest for that fragment); and areas
highlighted by you and others appear in various shades of green. The margin on the left shows
comments linked to the highlighted areas. Threaded comments (i.e., responses to existing comments) appear indented under the original comments. To see comments linked to highlighted text, you click in the text. The author bars (i.e., the bar above a comment that displays the name of the author) of all related comments are highlighted. To see the highlighted text to which a comment refers, you click a Jump to Marker icon in the author bar. To add a comment, you select a block of text using click-and-drag or other standard methods to select text and the comment box editor opens. To add a reply to an existing comment, you click Action and select Add Reply.

As participants engage in discussions, HyLighter provides a variety of “views” for working with the group input including (a) a table showing highlighted excerpts and associated comments with various sort and search options and (b) a split-screen format for editing that displays the HyLighter session on the left in a horizontal format (i.e., the margin panel is placed under the highlighted source instead of vertically along the side) and the source document in its native application on the right.

The design of HyLighter embodies certain conjectures about learning and social context drawn from the existing research and theory base of the learning sciences. For example, this includes social constructivism (Lave & Wenger, 1991), the theory of expert performance (Ericsson, Krampe, & Tesch-Römer, 1993) and knowledge-building communities (Scardamalia et al., 1989). Three key conjectures from the learning sciences that have guided the HyLighter design effort are:

- Design activities that make the thinking of learners visible and articulated to themselves and others. This is based on the premise that the thoughts that go on in the heads of students are most important.
- Provide students with frequent opportunities to reflect on and adjust their thoughts and arguments and engage in discussions with their peers and the instructor. By providing timely feedback, students have opportunities to clear up their thinking before misconceptions settle in for good and are further motivated to engage in the learning process.
- Promote development of metacognitive skills (i.e., capacity to monitor one’s thinking process, be aware of what one knows and does not know, and reflect on what one has
learned) and a positive disposition toward learning. Ability to learn, including self-regulation and self-assessment skills, is one of the most important outputs of the educational system.

To summarize, HyLighter tightly binds online asynchronous or synchronous discussions to specific sections of a text or image and helps to extract value from the collective thinking and interactions of contributors. Much as in the tradition of scholars during the Middle Ages, HyLighter blurs the line between authors and readers and brings rich social interaction and multiple perspectives to formerly static environments. From the broad perspective of the learning sciences, HyLighter enables three key functions:

1. Makes the thinking of teachers and students that are ordinarily hidden, become transparent and easily accessible for sharing with others, self-reflection, and feedback.
2. Allows users to continuously compare their developing understanding to others, assess performance, and monitor progress.
3. Supports efforts to organize, integrate, and synthesize ideas from multiple sources and perspectives.

**Faculty Experiences**

Three professors shared their experiences with HyLighter-enhanced learning and assessment activities in three different areas of the college curriculum. Their reports are part of an informal action research project aimed at evaluating HyLighter across the curriculum in order to improve classroom instruction and educational effectiveness. In this context, action research is defined as classroom-based studies initiated and conducted by teachers who systematically reflect on their teaching or other work and collect data that will answer their questions (Zuber-Skerritt, 1992).

Campbell Dalglish teaches screenplay writing at City College of New York (CCNY). He described how he used HyLighter to improve students’ writing and critical review skills. Oliver Grundman is in the Department of Medicinal Chemistry at the University of Florida, where he teaches graduate-level courses in online Forensic Science and Pharmaceutical Chemistry programs. He described the application of HyLighter to help students learn about chemical structures and analytical principles in pharmaceutical and forensic sciences. Hope Hartman is
a professor of education at CCNY. She described her use of HyLighter to implement an alternative multiple-choice assessment approach in her educational and developmental psychology courses (Hartman, 2010).

**Critical Review of Screenplays**

Writing a screenplay is one of the most complicated forms of creative writing. Anyone who dares take on this arduous task knows that critical review is essential in the development of a script. HyLighter was first tested in second semester college English classes to develop skills in analyzing, discussing, and writing responses to argumentative essays and strengthening skills in writing persuasive arguments (Lebow & Lick, 2003). This suggested the idea of using HyLighter to facilitate the screenplay writing process and support teaching and learning of this complex activity.

A writer must navigate through seven stages (two of them coming with a Writer’s Guild price tag) to produce the first draft of a screenplay. Once a first draft is completed, contracts are signed, production elements attached (e.g., input from producers, directors, actors, script doctors, and sometimes co-writers), and another process begins. This involves an entire development team working with the writer to create what is called the “production script.” In the business, this exchange is often referred to as “development hell.” The sharing of notes back and forth and rewrites from the author can all add up to many years of hard work, with potentially nothing achieved at the end in terms of a movie.

Between the first draft and the production script, the screenplay receives “coverage,” a two-to-five page document that evaluates the script in multiple ways. This allows a production company to quickly assess and decide whether or not they want to make the film or video without having to read the script. Coverage has three parts: (1) the “top page,” which contains a log line (i.e., a one or two sentence description designed to create interest in the project), the specifics of the script in terms of authorship, agency, genre, page length, copyright and, most importantly, a critical grid that has six parts: (a) theme, idea, and premise, (b) character, (c) plot/structure, (d) dialogue, (e) visual description, and (f) production value (quantitative and qualitative); (2) a summary, without opinion or commentary that simply reports the plot and characters; and (3) a critical commentary that embellishes the six elements of the critical grid,
supporting why the reviewer “recommends, maybe recommends, or passes” on the script. This three-to-five page “tool” is what gets passed among people in the industry and can determine whether a screenplay gets a second read.

As a teacher of screenplay writing for the last twenty-four years, I have found that getting my students to read and critically evaluate each other’s work is a challenge. Before computers and projectors for electronically displaying content became available, I would bring multiple copies of students’ scripts to class to share with others a week before a scheduled workshop. When computer technology arrived, I could project a script up on a screen, but still, students had to handout copies of their scripts the week before in order to get everyone’s feedback. At the end of class, students walked out with fifteen copies of scripts from fifteen students, and one from me with notes written all over them. I had no way of telling who was saying what to the writer, and I could not imagine being the writer having to sort through all those notes.

At the end of the year, the most frequent negative comment of students was that either they didn’t get enough feedback, or the feedback they were getting from classmates was not helpful. I had no practical way of reading what they were writing on each other’s scripts unless, of course, I was willing on a weekly basis to collect and read all 225 copies myself (for my 3 classes during a semester that would have meant reading 9,450 scripts), review them with comments, and then hand them back to the writers so they could continue revising.

Four years ago, when I visited the Center for Excellence in Teaching and Learning at CCNY and asked Hope Hartman, the Director, for a better way to review the work of my students, she introduced me to David Lebow and HyLighter. Immediately everything changed. Within weeks I had students using this software to review each other’s exercises and scripts. Students were able to get feedback instantly, I was able to read what they were saying to each other and comment on that, and suddenly the class was hopping with excitement. When we had our workshops, I could display the document from HyLighter on an LCD screen in class, hide all comments, have actors read through the script, and then bring up all the comments and have a real live critical review of the script with everyone participating. The dialectics that came up over what does and does not work began before class even started, and everyone was able to add to the comments during the class.
As a result of implementing various HyLighter-enabled practices, our class discussions took on a whole new level of relevance, meaning and expeditious review. Classes became communities of inspired writers who shared a common commitment to the value of critical revision. For the last four years, I have never read another teacher evaluation where a screenplay-writing student complained about not getting enough feedback. One student, who never spoke in class because English was her second language, wrote more on the scripts of her fellow students than anyone else in the class. Students loved her.

In addition to creating a sense of community and shared purpose, HyLighter provided a mechanism to increase the value of the coverage grid mentioned previously. Reviewers were able to annotate throughout the script where they thought weaknesses existed and add tags to their comments by selecting from a drop down menu of grid descriptors. Once a script is marked up, writers can retrieve all comments made on a particular coverage area - the dialogue, the theme, the structure, or the visual writing - and get the benefits of aggregating all of the inputs by coverage category as they work on the rewrite. In sum, HyLighter has been responsible for enhancing our learning experiences, relationships with and among students, and, most importantly, the work of students, so that they feel confident when they go into the difficult world of getting a script brought to the big silver screen.

**Online Graduate Classes in Pharmaceutical and Forensic Sciences**

Online platforms for the delivery of course content provide a broader spectrum of course content delivery and assessment options than traditional approaches. A recent report prepared for the US Department of Education entitled, “Evaluation of Evidence-Based Practices in Online Learning - A Meta-Analysis and Review of Online Learning Studies” (Means, Toyama, Murphy, Bakia, & Jonbes, 2009) focused on new approaches to teaching and learning that build on the capabilities of online platforms and advanced instructional tools. One of the findings of the report was that learners who were able to utilize interactive tools and control their learning process performed better than learners who used static tools that were instructor-controlled. Also, students who engaged in self-reflection by assessing their answers in comparison to other students in an online chemistry class benefited (Bixler, 2008).
The application of online and distance education courses that involve complex relationships such as chemical structures and analytical principles in pharmaceutical and forensic sciences is challenging. However, the above-mentioned meta-analysis and studies provide evidence that abstract principles can be successfully transferred into an online setting. The interactive and self-reflective features that HyLighter provides are ideal for student-student interactions, as well as for a collaborative approach to answering questions related to pharmacological, structure-based, and analytical problems.

The HyLighter tool was utilized as an additional assessment tool for student assignments in two graduate-level distance education courses at the University of Florida (www.forensicscience.ufl.edu and www.pharmchem.cop.ufl.edu). The courses were administered as asynchronous, text-based modules with animated and static graphics for illustration of chemical and analytical processes such as drug-receptor interactions or generation of mass spectra. The student demographics varied both in educational background (all students were required to have a Bachelors degree, preferably in a natural science such as biochemistry, chemistry, medicine, or related) and work experience (ranging from students having just finished their undergraduate degree to those working in the field for over 10 years). The classes utilized for implementation of HyLighter were “Fundamentals of Medicinal Chemistry (PHA 5433)” and “Forensic Toxicology 1 (VME 6613).” Both classes were taught by different instructors and during different terms without an overlap of students being enrolled in both classes.

The HyLighter assignments for both classes were scheduled towards the end of a respective module on mass spectrometry for Forensic Toxicology 1 and the end of the semester after all modules were released to students for Fundamentals of Medicinal Chemistry. Students were asked to either (a) comment on an area highlighted by the instructor or (b) highlight an area and write a comment or explanation themselves. For the Forensic Toxicology 1 assignment, 14 students were asked to interpret mass spectra of the illicit drugs cocaine and methamphetamine. Interpretation of mass spectral data is an integral part of the everyday work of a forensic toxicologist and, therefore, students need to acquire a basic understanding in this area.
In this first application of HyLighter, the instructor imported PowerPoint slides that included mass spectra images. He highlighted specific sections of various slides and added questions as *sticky posts* (i.e., comments that always appear at the top of a discussion thread in the HyLighter margin). Although HyLighter provides the instructor with the option to set permissions for independent review (i.e., students can see the instructor’s sticky posts and their own responses but not the responses of other students), the instructor set permissions to make all comments visible to all students throughout the exercise. The rationale for allowing students to see each other’s comments was to encourage them to engage with each other before submitting their answers. Also, the instructor wanted to compare this open approach to a two-part approach that required independent responses from students before allowing students to share and discuss their responses.

Students answered and discussed the questions associated with highlighted areas and came to conclusions for each. This was accomplished online in both real time discussions and asynchronously. The conclusions of students were either approved or corrected by the instructor. Self-assessment by students was provided on a grading scale ranging from 0-10. The self-assessments of students at the end of the exercise for the mass spectra interpretation were different than the instructor’s grading and revealed that students may be overconfident but can improve their skills by learning from their mistakes. This observation is consistent with research on metacognitive knowledge monitoring which evaluated how well students distinguish between what they know and do not know. Results suggested that accurate monitoring is an important variable in school learning (Tobias, Everson, & Laitusis, 1999).

The second course in which HyLighter was used as an educational tool combined the knowledge acquired by students after finishing all required module assignments. The exercise was intended to provide 23 students enrolled in the course with the opportunity to apply and transfer their theoretical knowledge into an actual practical example. The HyLighter assignment was mandatory. The course “Fundamentals of Medicinal Chemistry” introduced basic concepts related to the physicochemical properties of a drug structure as well as principles of what the body does with a drug (pharmacokinetics) and what the drug does to the body (pharmacodynamics). Similar approaches have been evaluated for online medicinal chemistry courses offered to pharmacy students (Alsharif & Galt, 2008).
After students worked on individual homework assignments and completed online timed quizzes, the HyLighter assignment was used to summarize the concepts of the course and then make students apply their knowledge to a new structure. All instructional material was prepared as PowerPoint slides and imported into HyLighter as images. Unlike the Forensic Toxicology 1 assignment where students could see all comments from the beginning, this second HyLighter assignment was split into two parts. The first part required students to independently respond (i.e., students could not see the responses of their peers) to the teacher’s sticky-post questions followed by a second part that allowed students to see all responses and discuss their answers.

The instructor posted questions in the margins linked to highlighted areas of each slide and provided initial instructions on how to use the HyLighter tool. Students initially gave individual responses without seeing the responses of other students. After a deadline had passed, the instructor changed HyLighter permissions to reveal all comments and encouraged discussions among students. Students were able to comment on each other’s responses using HyLighter’s reply feature and many recognized and acknowledged if they initially had made a mistake. The instructor also provided feedback to students and evaluated them based on their initial responses and contributions to follow-up discussions. This process was supplemented with chat sessions within the platform used for module and assignment administration. Figure 2 shows a slide from the “Fundamentals of Medicinal Chemistry” activity.
Figure 2. A PowerPoint slide in HyLighter. The instructor has added two questions linked to different sections of the graphic. Students independently respond to the questions and are able to see the responses of their peers and the instructor when the instructor changes HyLighter permissions.

During chat sessions, students provided positive feedback about the HyLighter assignment. They were able to apply acquired knowledge and experience and see the relevance of their new knowledge to the drug development process. The HyLighter assignment also helped in reviewing material from undergraduate classes such as basic analytical techniques, physicochemical properties of chemical structures, basic applications of chemistry to the drug design process, and biotransformation processes.

In conclusion, the main advantages of using HyLighter as an instructional tool in distance education courses as administered in the pharmaceutical and forensic sciences programs at the University of Florida were:

1) HyLighter was an effective tool for students and instructors to transfer knowledge acquired in written modules into practical examples and authentic assessments.
2) Students were able to evaluate and compare their own answers with those of their peers which provided additional discussion incentives and increased engagement.

3) HyLighter enabled collaborative student approaches for alternative assessment activities that complemented quizzes and individual assignments.

**HyLighter-Enhanced Multiple-Choice Testing**

Multiple-choice tests have a long but not always illustrious history in education across the curriculum and levels of schooling. Teachers often like them because they are easy to administer and score. Students often like them because the answer is given to them to recognize, so they do not have the more intellectually demanding task of recalling the answer. Also, if they do not know the answer, they can always guess and usually have at least a 25% chance of getting it right.

On the other hand, many educators have pointed out a limitation of multiple-choice items - no credit is given to alternative answers to questions. A student might get the “wrong” answer, but for good reasons, such as a creative approach to thinking about the question or problem, or because the question itself is vague or ambiguous. In other words, wrong can sometimes be right and right can sometimes be wrong. A student can get the “right” answer by guessing while not knowing the material, or by having a completely wrong or only partially correct understanding of the material.

As a cognitive psychologist teaching educational and developmental psychology to preservice and inservice teacher education students, I wanted to (a) probe the reasoning underlying students' answers to multiple-choice items and (b) model for teachers an alternative approach to multiple-choice testing.

Consequently, I uploaded multiple-choice tests in HyLighter and used the comment feature to require students to explain the reasons for their answers. Students received equal credit for both their answers and the reasons underlying their answers. Each test had 20 items, so each question was worth 5 points. Two and a half points were awarded for the correct answer and the same for good reasoning. In some cases partial credit was given for students' reasoning.
Enhanced multiple-choice testing allowed me to obtain a better understanding of what students knew, misunderstood, confused, or failed to grasp. The approach also revealed patterns of errors and misconceptions. This feedback guided my subsequent instruction with particular classes soon after the tests and guided my plans to teach some material more effectively in the future. This procedure also forced students to think about and learn the material more deeply than they would have for a typical multiple-choice test. It also helped students reflect on their own thinking and learning so they could study more effectively for future tests.

In addition to the feedback I received about students' learning and the effectiveness of my teaching, students received feedback about their own and each others' learning. Immediately after taking the test, students were able to click on questions to identify the correct answer. Shortly after the whole class had finished their test, students were able to see models of good explanations of answers by their classmates. During a subsequent class, I discussed the forms and functions of feedback obtained through this enhanced, multiple-choice testing and identified specific misconceptions students had about the material in the course.

The second time students engaged in enhanced multiple-choice testing via HyLighter, they were much more successful for a number of reasons. They were better able to study at the level of depth and with methods needed to master content well enough to produce good reasons for their answers. They knew more about themselves as learners and test takers. They had learned from their peers how to provide more accurate and thoughtful explanations of their multiple-choice selections. Students were also more successful the second time because I provided them with feedback about the types of explanations that were made on the first test. In class, we discussed successful and unsuccessful answer explanations. This helped them to plan their subsequent test preparation with these potential problems in mind.

Successful explanations often involved a combination of categories such as explanation/description and elaboration and example. This is illustrated by the response of one student to the question: How does the nature of the learning environment affect teacher learning?

a. Learner-centered environments emphasize teachers learning how to transmit important information to students.
b. Knowledge-centered environments encourage teachers to rethink how they teach particular subjects.

c. Assessment-centered environments indicate that classroom teacher feedback is greatly overrated in importance.

d. Community-centered environments emphasize the importance of teachers' independent thinking, learning and problem solving.

The correct answer, b, was successfully justified by one student with:

Just because you are an expert does not mean you will be able to teach material. Just because you are a skilled pedagogue does not mean you will be able to teach any subject. There needs to be a balance between subject knowledge and pedagogical content knowledge. A knowledge-centered environment will encourage teachers to reexamine strategies they have used in the past. In such an environment, a physics teacher might realize that his/her instruction could be improved by focusing on big understandings rather than individual equations.

Common unsuccessful combinations were explanations including categories such as misconceptions, personal opinion, and part/whole. This is illustrated by the response of one student to the question: According to *How People Learn*, one of the most important features of the new learning technologies is:

a. The ability to develop students' basic skills.
b. The ability of learners to interact with others.
c. An emphasis on the traditional curriculum
d. They build on students' prior experiences with technology.

The correct answer is b, because a recurring theme of the book's chapter on technology was that technologies have valuable uses as contexts for social interactions that support learning,
and many examples of this were given. An example of a wrong answer is d, and a given unsuccessful student explanation is as follows.

The use of technology in the classroom has to be built upon their prior knowledge. The proper scaffolding needs to be in place so a student can achieve & narrow his ZPD [i.e., the zone of proximal development is the difference between what a learner can do without help and what he or she can do with help] with the help of the teacher & the use of technology in the classroom.

On the other hand, a student received partial credit for the wrong answer d, because of demonstrating understanding of the social interaction benefits of technology. Though community aspects of choice b are somewhat true, and there are several projects that have shown the benefit of e-based cooperations & collaborations, I tend to think that technology is best employed when it facilitates the learner-centered environment.

On the second test, many answers were developed more fully and some students referred to the enhanced multiple-choice procedure as involving a combination of multiple-choice and essay methods. In one case, students' explanations of their answers revealed that a test question was problematic because so many students misunderstood it. Consequently, the enhanced multiple-choice testing procedure helped me to prepare more effectively for the second test by facilitating metacognitive question construction (i.e., taking into account what makes sense to students when formulating test questions).

At the end of the second test, as an option, students were able to provide feedback on their reactions to the experience of taking the enhanced multiple-choice test through HyLighter. Following are examples of students' comments, both positive and negative:

Positive

• I thought this worked very well. I liked the fact that it made one think in depth about the answers and try to justify them.
• This was the most progressive test taking experience I have ever been involved in. It's amazing how little straight multiple-choice tests reflect regarding students' conceptions.
• The whole process of highlighting made me very critical of my answers and also made me read each word carefully in the answer choices.
• Responding to the test was kinda cool. And I think as a teacher I would like to have the ability to see inside my students' heads at the time they take the exam. So overall I would say a good experience.
• Would be especially good for math tests where students can guess the answer or cheat without actually knowing the concepts.
• Provides an opportunity to easily assess students' progress.
• I thought this worked very well…It allowed me to see gaps in my thinking and knowledge.

Negative
• This test was difficult. I started out strong but felt weaker at the end. Some of the questions were more detail oriented than I expected, and it took much longer than I expected…This must take hours to correct!
• I wasn't exactly sure to what extent we were to explain ourselves and that might have been helpful to know.
• It should be practiced first. Surprises aren't good, especially when you're taking a test.

Enhanced multiple-choice testing through HyLighter was a powerful experience for my students and me. During class discussion many of them reported wanting to do something similar with their own students, as they valued the window into the thinking and reasoning of students provided by social annotation technology. In the current era of high stakes multiple-choice tests, gaining insight into students' thoughts and knowledge while engaged in multiple-choice testing not only has important educational implications but also political, social, and economic implications too.

Conclusion
Three cases have illustrated uses of social annotation to promote student-to-student and teacher to student interaction tied to different types of content or source materials. In screenplay writing classes, students engaged in a type of reciprocal peer review of their drafts. By establishing an environment where rich feedback from peers and the instructor was the norm, students experienced the value of giving and receiving constructive feedback. In online Forensic Science and Pharmaceutical Chemistry classes, students engaged in collaborative learning and assessment activities that helped promote self-assessment, increased engagement with complex concepts, and support of transfer. Finally, HyLighter-enhanced multiple-choice testing in preservice and inservice teacher education classes, facilitated error analysis, and provided scaffolding for students to transition from lack of knowledge or understanding to mastery of material deep enough for transfer of learning. In sum, HyLighter-enhanced practices fostered self-efficacy, thereby resulting in cognitive, affective and social benefits for students and improved quality of instruction for teachers.

Brown and Duguid (1989) have pointed out that documents not only deliver information but also build and maintain social groups. From their perspective, the document is a medium for the negotiation of meaning, and, on this basis, they have recommended developing technology to improve the means of negotiation. Social annotation applications satisfy this criterion through three key functions:

- Makes the thinking of teachers and students that are ordinarily hidden, become transparent, visible, and easily accessible for sharing with others, self-reflection, and feedback.
- Allows users to continuously compare their developing understanding to others, assess performance, and monitor progress.
- Supports efforts to organize, integrate, and synthesize ideas from multiple sources and perspectives.

However, what we understand about how to implement and manage social annotation systems across disciplines is relatively limited. In order to realize the full potential of this form of social media for education more research is required on how to adapt technology and practices for various contexts of use.
Broad goals of the next phase in development of HyLighter include (a) develop new functions to increase versatility and integrate with other social media and learning management systems and (b) modify and improve HyLighter and related practices based on feedback through a collaborative relationship with practitioners in the field. In sum, HyLighter is an emerging set of tools and methods that support various document review practices to harness the cognitive and social-interaction potential of knowledge-based social networks and accelerate learning, creativity, and improvements in performance of members. At its core, HyLighter builds on the principle that our own views grow and are enhanced by remaining open to the views of others.
References


