Enhancing the Classroom Experience with Faculty Curated Discussions

by

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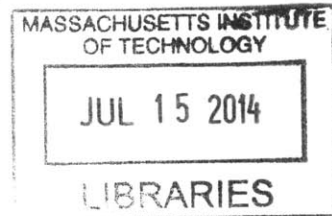in partial fulfillment of the requirements for the degree of

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Abstract

We identify a number of metrics that attempt to recognize collaborative discussion in online annotation tools and class forums. We hypothesize that posts and questions that lead to collaborative discussion are likely to achieve the same effect if posed again. To study the effects of comment reuse, we build content curation tools that allow content that appears to stimulate collaborative discussion to be promoted or reused from previous class offerings. NB, a social annotation and discussion platform, is extended to provide such tools for annotation reuse, content promotion and curation, and content analysis based on certain metrics as potential indicators of comment quality. Related work by research partners shows encouraging results regarding the reliability of our metrics. We assess these tools through instructor interviews and user studies, establishing their usability. This work opens the door for future work on sustainably interactive and engaging learning.

Thesis Supervisor: David R. Karger
Title: Professor

Acknowledgments

I would like to thank Sacha Zyto, without whom NB would still be just an idea. For his guidance throughout these past few years, I express the sincerest appreciation. I also wish to thank Kelly Miller for being an instrumental partner in studying annotation reuse.

Last, but certainly not least, I extend many thanks my adviser, David Karger, for his guidance and mentorship.

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Chapter 1

Introduction

The advent of the Web brought with it many opportunities to enhance education through online tools. The quest for computer-enhanced learning began even earlier, with systems like PLATO [1] and computer games [2] like 'How the West Was Won'. Yet, until recently, computer software and the Web have not been transformative in mainstream education. As the world seemingly begins to pivot towards computer-enhanced learning both in MOOCs and in regular classroom settings, it is increasingly vital to understand how computers and the internet can make reading and learning better—to understand when technology is effective in education, and when it is not.

Two related tools are gaining traction in augmenting and supporting learning experiences both in university classroom settings and online-only courses: discussion forums and annotation tools. Recent trends show an expansion in the reach and uptake of such online learning tools. While these tools have increased the ability of students to find or discuss material, technology that empowers educators to steer and guide student discussions has lagged behind.

Our base assumption is that class discussion is a valuable component of learning, as it holds the potential to promote *constructive* and *interactive* learning. This claim is supported by the ICAP hypothesis [5], which will be discussed in greater detail in section 2.1.

Results show that social annotation and discussion tools *can* successfully improve the learning experience by a number of metrics [30]. However, educators still have not

mastered the ability to induce, reliably and repeatedly, constructive and interactive learning using these tools. We know how to identify "good" discussions according to a range of criteria after they take place, but still do not know how to induce students to engage in such discussions.

The reuse of comments and discussions from previous course offerings has yet to be explored and has the potential to answer two important questions: First, do "good" questions—that is, questions that lead to "good" discussions—do so reliably? Second, through controlled experimentation with comment reuse: Which criteria will more reliably predict what kinds of annotations correlate with discussions that promote learning and enhance course performance?

As we come closer to answering these questions, we can begin to empower faculty to curate content and discussions. If educators know what comments will cause constructive and interactive engagement, then they can promote and moderate questions, comments, and discussions to foster higher levels of engagement in learning. Further, future offerings of a class could reuse the most successful questions, comments, and discussions, allowing annotation tools and discussion forums to reliably lead to constructive and interactive engagement.

1.1 Problem Statement

Instructors and educators should be empowered with tools allowing them to foster higher levels of learning engagement among the students. As courses move online, and class sizes increase (in MOOCs, for example), it becomes increasingly important to stimulate active learning without the need for direct instructor intervention. In this work, our aim is to enable instructors to curate classroom interactions to promote certain kinds of learning engagement that have been shown to work more effectively.

1.2 Contribution

In this work, I extend NB, a social annotation and discussion platform, to provide tools for class section management, annotation reuse, content promotion and curation, and content analysis based on a number of metrics that are potential indicators of comment quality. In doing so, we provide basic indicators of comment and discussion quality, and provide the tools for further work on reliably stimulating interactive engagement in learning.

1.3 Outline

In chapter 2 we survey existing works and literature to set the background for our work. We discuss theories of constructive and interactive learning, the role of instructors online, survey a range of discussion forums and annotation tools currently in use. In chapter 3 we describe in greater detail the motivation behind this work in influencing future work. Chapter 4 provides an overview of our annotation tool—NB—and how it fits in the picture. We then illustrate the design of our class sectioning interface in chapter 5, and our content curation tools in chapter 6, and evaluate it based on interviews with instructors and faculty members in chapter 7. Final thoughts and recommendations for future work are presented in chapter 8.

Chapter 2

Background

Our goal is to build tools that allow instructors to promote higher levels of learning among their students. We begin by discussing what it means for students to be engaged in active learning, and exploring contemporary views on the effectiveness of the role of the instructor in the classroom. A range of related works suggest that online tools such as discussion forums and annotation platforms hold great potential in education.

To better understand the landscape of available tools, we survey a number of discussion forums used in education, including traditional bulletin board software, collaboration tools such as Piazza, and public question and answer sites such as StackOverflow. As we shift gears to explore annotation tools, we must first understand the different *registers* in which annotation can take place: marginalia, encyclopedic, scholarly, and discussion. With these registers in mind, we compare and contrast a number of contemporary annotation tools: Annotation Studio, Rap Genius, and Nota Bene (NB). In doing so, we highlight the key distinguishing feature of NB—its focus on discussion, and its view of annotations as a platform for discussions. Using the ICAP hypothesis as our main justification, we hypothesize that much of the demonstrated benefit of using NB in classroom settings comes from the interactive and collaborative process, rather than the content itself.

Before testing this hypothesis, it is important to highlight the deficiencies of regular discussion forums, namely the cost associated with task switching. As we do

so, we re-introduce NB as a platform for "situated discussions" and re-frame our research areas of interest. The chapter ends by highlighting important work on content curation that is being explored by our research partners using NB.

2.1 Interactive Learning and the ICAP Hypothesis

Educational technology must continually attempt to push students to higher levels of engagement in learning. Micki Chi at the Department of Psychology in Arizona State University did some important work on engagement in learning by developing the ICAP model [5], a *"framework for differentiating levels of cognitive engagement in 'active learning'."* According to Chi's ICAP Hypothesis, the levels of engagement, in decreasing order, are interactive, constructive, active, and passive. Many online learning and classroom tools seek to elevate students' engagement with the material to the higher levels.

In [6], Chi describes the four levels of engagement as follows: **Passive engagement** is a level of engagement characterized by simple *receiving* of information. With passive engagement, a student pays full attention and absorbs the material without distraction. A passively engaged student, however, is not taking notes or summarizing the material. **Active engagement** is characterized by *selecting* and *summarizing*. Verbatim notes of parts of a lecture, or summarization through copy-and-delete are examples of activities of actively engaged students. **Constructive engagement** is characterized by *generating* and *explaining* patterns. A student here records notes and summarizes them in their own words. **Interactive engagement** is characterized by *collaborative* patterns. Interactively engaged students discuss and extend course materials, build and elaborate on each others' contributions, can argue about differing views, and provide justifications for their assumptions.

Online discussion and annotation tools show great potential in inducing higher engagement levels. Even simple interactions such as highlighting course contents

can be associated with active—and sometimes constructive—engagement. Many of the activities found in online discussion forums are associated with interactive and constructive engagement. This fact makes discussion forums a promising avenue of exploration when developing learning tools.

2.2 Faculty-Student Interaction

Educators are often concerned about the role of the instructor in teaching and the level of interaction the instructor needs to provide to the students. According to Endo and Harpel in [10, pp. 126–127], interactions between students and the faculty outside the classroom are often more effective than classroom interactions, and students' learning outcomes are affected by the frequency and quality of such interactions. In addition, Li *et al.* show in [16] that students prefer *asynchronous* methods of student-faculty interactions outside the classroom.

Other studies, however, suggest that faculty interaction might not significantly impact student performance. Tomkin and Charlevoix argue, "instruction intervention had no statistically significant impact on overall completion rates" in an online MOOC setting A/B test [27]. In the study, instructor intervention did have a slight impact on the amount of forum-based discussions taking place. The study calls into question the importance of *direct* faculty intervention in online classes, specifically MOOCs. This important result addresses concerns regarding the scalability of MOOCs.

While direct faculty involvement might not be essential, some form of faculty curation might still hold potential. An important alternative to instructor intervention is direct student-to-student support and discussion. Direct student interaction might indeed prove to be *more* useful than instructor intervention. Allowing instructors to promote and nurture discussions in a scalable way (by promoting or reusing posts that meet certain criteria) could in fact be an important way to create scalable online classes and enhancing the learning process.

2.3 Contemporary Educational Discussion Forums

Discussion forums are important tools in many class settings. In traditional classes, forums provide students the ability to asynchronously ask questions and discuss the material. In MOOCs, discussion forums are oftentimes the primary method for student-to-student and student-to-teacher communication. In this section, we will introduce three discussion forums used in education: traditional bulletin board software, Piazza, and Stack Overflow. Our tool, NB, will be formally introduced in later in section 2.5, as both an annotation tool and a discussion forum.

Traditional bulletin board software[1], have been shown to promote active learning in the classroom [8, 15]. Bulletin board software provides a medium for linear or threaded electronic conversation. Threads are posted in different *forums* or *categories* which are hierarchically organized, often by topic or purpose. Within each category, threads are often ordered by most recent activity. Students browse through threads to "listen in" on other discussions, and can participate by starting or replying to a thread and engaging in discussion.

Other discussion forums like Piazza specifically target education uses. Piazza defines itself as an "online collaboration platform" that enables participants to start notes, ask questions, answer questions, and discuss these answers. Piazza mainly provides "Questions and Answers" tools, but also supports commenting and linear discussions to take place. Piazza has experienced significant growth and is used widely in many universities[22]. In Piazza, questions and notes are displayed in a single pane that includes all other notes and questions in the class, ordered by the most recently asked question. Posts, however, must have at least one tag, and the list of posts can be filtered through these tags.

In addition to forums targeting a single class, larger forums are used by many students as a resource. A prominent example of such forums is Stack Overflow. While not a discussion forum *per se*, Stack Overflow is an online forum for asking and answering questions. It is particularly popular in computer science as a valuable

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[1]examples include vBulletin, IP.Board, phpBB, and most recently Discourse.

resource [3]. Students use Stack Overflow either by directly asking questions to the community or by formulating a question and searching for it. In both cases, students end up formulating questions and reading answers to these questions, thus engaging in some form of constructive or interactive learning.

Discussion forums in general certainly play a major role in education today. Whether by participating in a forum restricted to a given class or by using public discussion platforms as a resource, students can be enriched by witnessing and participating in discussions. Forums promote the higher levels of engagement by encouraging students to formulate their own questions to pose or to search for, and providing answers to these questions. Forums often provide a platform for free-reigning discussion that allows students to creatively discuss and build upon on others' ideas.

With these in mind, we move on to discuss annotation tools. What levels of engagement do annotation tools provide? Are all annotation tools similar? In what ways are they better than discussion forums, and in what ways to they lag behind?

2.4 The Different "Voices" of Annotation Tools

While many education-focused tools are grouped together as "annotation" tools, annotating can occur in different *registers*, and annotations can have different *voices*. Annotation registers of interest are marginalia, encyclopedic, scholarly, and discussion registers [14]. Each annotation tool could aim to support one or multiple registers, but each register should first be understood independently.

A *register* of annotation describes the type of usage of annotations within a tool or document. A tool providing annotation as an end in itself is focused on the *marginalia* register; a tool aiming to create reference annotations that expand on works is focused on the *encyclopedic* register; a tool aiming to provide a platform for analysis and critique is focused on the *scholarly* register; a tool aiming to facilitate discussion on a document is focused on the *discussion* register [14].

2.4.1 The Marginalia Register

Marginalia are any highlights, comments, illuminations, or scribbles on a text. Such annotations encode a reader's progress throughout a text and his or her interpretation of it [17]. These notes could be written with future readers in mind as an audience, but do not need to. Marginalia can be collaborative, as one reader can read, respond to, expand, or contradict a previous reader's annotations. Such "collaboration" historically has not been interactive; texts typically travel from one reader to another without an opportunity for back-and-forth discussion through marginalia [18, 14].

Any comment or annotation can be considered *marginalia*, including comments and annotations made in other registers. What makes the *marginalia register* unique is its focus on annotation *per se*. Other registers, on the other hand, use annotation instrumentally to produce guides, commentary, or discussion on a given work.

Modern annotation tools that focus on marginalia similarly place more emphasis on producing and expanding on marginalia, than achieving interactivity through marginalia [18].

2.4.2 The Encyclopedic Register

When using an encyclopedic voice, the writer aims to explain and demystify a text. Each encyclopedic annotation is a miniature article that expands on the meanings and intricacies of a part of a text, or a text as a whole. Encyclopedic entries might engage in analysis (literary or otherwise), but they do so while remaining largely impartial. Encyclopedic annotations might be authored collaboratively by multiple individuals, but often appear as if authored by a single person. Discussion, therefore, rarely takes place in encyclopedic annotations [23, 14]. While discussion might be essential to resolve disputes or coordinate various aspects of annotation authorship, these do not take place in the annotation itself. Instead, discussions are seen as instrumental to producing authoritative, informative, encyclopedic annotations.

Modern tools that aim to produce encyclopedic annotations share many of the goals of Wikipedia and other collaborative encyclopedias: to make certain texts or

topics more accessible [14]. An annotation tool placed in the encyclopedic voice expects most users to be passive consumers of the resulting materials.

2.4.3 The Scholarly Register

Unlike encyclopedic annotations, discourse is an important part of the scholarly voice. Scholarly annotations can be similar to encyclopedic annotations in that they sometimes explain and demystify texts, but differ in that they can also offer the scholar's own views and perspectives. In literary works, for instance, the scholarly voice involves literary analysis and criticism [25]. The scholarly register neither requires nor precludes discussions in annotations. While threaded discussions provide opportunities to enrich scholarly discourse, some annotation tools continue to promote quality commentary without supporting threaded conversation [13].

Modern annotation tools that aim to produce scholarly annotations expect readers, like scholars, to interact with the text: analyze it, critique it, and build upon it. Like real scholars, readers can engage in scholarly discourse, discussing and debating with one another the merits of the original work or their respective responses [14].

2.4.4 The Discussion Register

Discussion forums provide users with a platform to start and participate in discussion threads. An annotation tool provides a unique type of discussion forum, where a user starts a thread by placing an annotation on a text, allowing other users to respond to comments on that thread. In the discussion register, annotations are often phrased as questions that require answers or prompts that call for responses.

2.4.5 Relation to the ICAP Hypothesis

In all of these registers, a learner who is annotating is engaged at higher levels of engagement than a passive learner. In this section, we will demonstrate how each of these registers can promote higher levels of engagement according to the ICAP hypothesis.

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Marginalia can span a wide range of engagement levels. Simple *selecting* and *summarizing* annotations signify basic active engagement. More often (and more importantly), marginalia include *generating* and *explaining* patterns, which signify constructive engagement. Authoring marginalia therefore predominantly involves constructive engagement, while reading, expanding on, and responding to the marginalia of others would consist of interactive engagement.

Similarly, authors of encyclopedic annotations are mostly engaged at the constructive and interactive engagement levels. They display generating, explaining, and collaborative patterns when authoring and expanding annotations. For those merely consuming the content, who are the majority[2], however, the engagement levels will not be affected by the annotation tool itself, but rather how the user chooses to read and interact with the annotations.

As for the scholarly voice, through critiques, analysis, and scholarly discourse, annotations taking place in this voice also reflect constructive and interactive engagement levels. Readers and annotators acting as scholars exhibit both generative and collaborative patterns [25, 13].

The final register we introduced, the discussion register, is heavily related to interactive engagement. Students who ask questions show signs of active engagement, by identifying and selecting portions of a text that are unclear, and seeking clarification on it. Students who answer questions also show signs of active and constructive engagement, either selecting portions of the text that correspond to an answer for a given question, or generating conclusions from a text that address a given question. General back-and-forth discussion on the material exhibits patterns of collaborative interactions that are indicative of interactive engagement.

	Annotation Studio	Rap Genius	Nota Bene (NB)
Register & Voice	Marginalia and Scholarly	Encyclopedic	Discussion and marginalia
Annotation audience	Class or sub-group	Global	Class or section
Annotation as a unit of...	Analysis & Critique	Analysis	Discussion (thread)
Annotations overlap	Yes	No	Yes
Discussion Support	None	"Suggest Improvement"	Discussion Threads
Emphasis on	Close Reading	Analysis & Interpretation	Situated discussions

Table 2.1: Summary of available annotation tools.

2.5 Contemporary Annotation Tools

Each annotation tool is designed with on or more of these registers in mind. In this section, I introduce three annotation tools in use today: Annotation Studio, Rap Genius, and Nota Bene (NB). While some of these tools can technically support other annotation registers, their interface, design, and—in the case of Rap Genius— moderation policy, encourage annotations to fall within a restricted subset of these registers. Table 2.1 presents a summary of the available annotation tools. The registers used by each tool explains major differences between these tools; for instance, NB is the only tool that supports discussions *within* annotations.

Annotation Studio [13] is an annotation web application developed by the Hyperstudio group as a joint project between the MIT School of Humanities, Arts and Social Sciences and the MIT Comparative Media Studies/Writing program. The tool focuses mostly on the marginalia and scholarly registers; Hyperstudio, the creators of the tool encourage readers of literature to engage in "close reading" through Annotation Studio to engage with the text. The faculty behind Annotation Studio encourage students to participate in scholarly discourse. Wyn Kelley at MIT describes Annotation Studio as promoting the idea of "students as editors". The audience for annotations on each work is limited to a particular class or sub-group of the class. Annotation Studio does not support linear conversations or threaded discussions to take place *within* annotations. Instead, scholarly discourse takes place across annotations. In Annotation Studio, students are encouraged to share their annotations and

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[2]The implicit argument is this: for encyclopedia-style resources with large audiences, the number of viewers is typically much larger than the number of editors. By way of example, compare monthly Wikipedia page views [28] and all-time Wikipedia page edits [9].

observations. To promote scholarly discourse and the sharing of contending views, Annotation Studio allows students to author annotations that cover overlapping parts of a text, thus enabling multiple students to each share their own view. This will not be the case for our next example, Rap Genius.

Rap Genius [24, 12] and the wider Genius platform is a collection of annotation web sites with which any user can read and annotate song lyrics, poetry, short stories, novels, and articles. Unlike other annotation tools, annotations in Genius are non-overlapping; no two annotations can intersect. The effect of this is that each sentence or section has at most one annotation describing it. This makes sense if we describe Rap Genius as an encyclopedic annotation platform: each part of the text should have a single authoritative annotation describing it. In addition, Rap Genius annotations are wiki-like collaboratively-edited blobs of rich text. The annotations themselves do not include discussion threads, though a commenting feature exists as a platform of suggesting edits to an annotation. Rap Genius places itself firmly in the encyclopedic register, with strict site-wide rules on grammar, style, citations, and content quality [14]. The audience in Genius is public by default, though it supports private-to-class documents and annotations for educators using Genius. The goal of Genius is to augment, explain, and de-mystify texts; Jeremy Dean, "Education Czar" at Rap Genius, says that the Genius platform is successful if—for a particular work—the annotations 'complete' the work, leaving 'nothing else to add'[14]. The platform's aims can be compared to those of Wikipedia; the goal is the text and the content, not necessarily the process by which the content is created.

NB (short for *nota bene*, Latin for "note well") is an online social annotation tool, developed by the MIT CSAIL Haystack Group. Zyto *et al.* recently highlighted successful deployments of NB in real classroom settings [30, 29]. As an annotation tool, NB is mainly concerned with the discussion register, aiming to provide a *situated discussion forum*; a forum in which threads are organized *on* a document by their physical location. While NB's success has been demonstrated and documented in numerous isolated cases, it remains to be shown if the benefit of NB comes from the added content, or the *process* of creating the content. This uncertainty in turn

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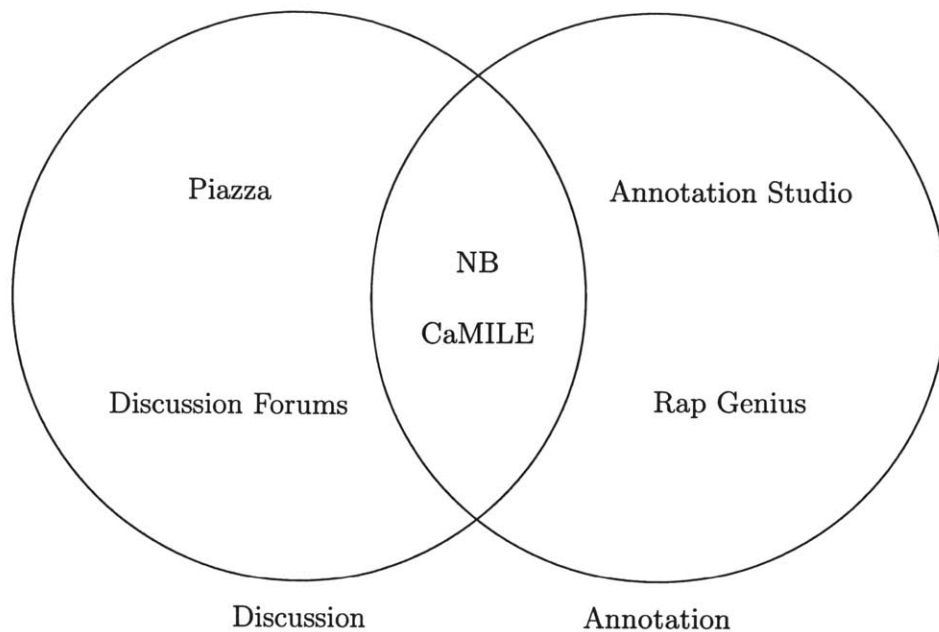
Figure 2-1: Summary of Discussion Forums and Annotation Tools

raises the question of what should happen to annotations after a course offering is complete: should an annotation live on with the original work to supplement and eventually perhaps improve it (*a la* Rap Genius), or is the real value of annotations the collaborative and interactive process of asking and answering questions, making observations, arguments, and counterarguments?

Armed with the ICAP hypothesis, we hypothesize that much of the benefit of NB comes from the *process*, rather than the content in its platonic form.

2.6   Annotation Tools as Discussion Forums

Discussion forums offer many benefits in class settings, but many also pose challenges due to the high cost of task switching between studying the material and participating on the discussion forum [21]. This problem manifests itself more generally: two important components of learning are absorbing new information, and asking clarifying questions on this information. In today's virtual world, these two modes of learning take place separately: users and students learn and absorb new information

through online textbooks, articles, and wikis, but they discuss and clarify questions using discussion boards or other social tools. Such partitioning of the locations of the different aspects of learning means that students must endure impedances from task switching [21]. This task switching cost slows down the overall learning process.

Other tools have been developed in an effort to achieve the same goals as those of NB. A prominent example is CaMILE [11], a system that brings the discussion closer to the content by allowing authors to designate locations where conversations can take place within an HTML document. Figure 2-1 shows a numbers of tools we have discussed and how they are related, with both CaMILE and NB representing discussion-focused annotation tools. The CaMILE paper is significant because it identifies some criteria for effective collaborative learning, allowing us to arrive at useful metrics and measurements to determine the effectiveness of NB.

The CaMILE tool is seen as a platform for "anchored discussions". The goal of NB is to build on the concept of anchored discussions—turning them into situated discussions: conversations that take place *anywhere* on the document. In doing so, we acknowledge the importance of context in discussions, but reject the need for strict, instructor-defined anchors for such discussions.

Chapter 3

Motivation

Given the rising prevalence of online annotation tools, I aim to explore further an area that has not been sufficiently studied: annotation reuse. In this thesis, the bulk of the work describes the design, building, and evaluation of tools that enable certain types of content curation, including annotation reuse. While the thesis itself does not evaluate the merits of annotation reuse, I develop a number of *metrics* that identify candidate comments for reuse. These metrics are also crucial in evaluating resulting conversations. The metrics to find candidate threads are used by Miller *et al.* to reuse a number of comments in past offerings, and produced encouraging data about the effectiveness of annotation reuse [20].

From a design point of view, the aim of this thesis is to produce a number of related tools that allow instructors to curate conversations in their online discussion forums. These include annotation reuse from previous offerings of the class, content promotion across sections, and content moderation. The usability of the design is evaluated through faculty interviews and user studies.

A successful design that easily enables content curation (including annotation reuse), coupled with data from the Miller *et al.* study suggesting the repeatable and reliable success of comments and threads with certain characteristics [20], makes a compelling case for the use of content curation tools and encourages future work on the topic of comment and thread reuse. Ultimately, this is the over-arching goal of my thesis work: creating a compelling case for future work on what makes comments

and discussions good by using controlled experiments involving annotation reuse.

This work takes place in the context of the MOOC revolution and concerns about the scalability of online classes. By inching closer towards techniques that encourage students to learn from other students, concerns about the scalability of student-instructor support and interactions are addressed.

3.1   Metrics

In this thesis, I hypothesize that comments and annotations that lead to collaborative learning in one offering of a class are likely to lead to collaborative learning in future offerings of the class. To test this hypothesis, it is important to develop candidate metrics describing which threads hosted collaborative learning. These metrics are applied in two different contexts: First, to design and develop a tool that enables the selection and transfer of annotations that fit these metrics into future offerings of a given class. Second, to evaluate the *performance* of a given approach to curation in a repeated offering of a class.

In their CaMILE paper [11], Guzdial and Turns define three criteria for the effectiveness of collaborative learning: broad participation, sustained discussion, and focus on class topic. NB's first paper provides baseline metrics, based on these criteria. Metrics shown in the Zyto *et al.* paper are relevant when assessing faculty-guided discussions for the purpose of out current work [30].

We will use two metrics that correspond to Guzdial and Turns' first and second criteria: As a measure of *broad participation*, we will rank threads by the number of different students in the class who participated in the discussion.   As a measure of *sustained discussion*, we will rank threads by the number of replies to each thread.

What remains is a method to assess *focus on class topic*—while our comment and thread transfer tool will not infer anything about focus on class topic, the comments we transfer can be vetted by instructors performing the curation to ensure the criterion is met.   When evaluating imported threads, *focus on class topic* is an additional criterion that assesses the "goodness" of a certain thread, and whether or not our

other goodness criteria correlate with it.

An additional quality metric is *thread quality*, based on the methodology by Kelly Miller [20], is useful when assessing resulting conversations. Thread quality is calculated for each thread as the average *comment quality* across each individual comment within it. Each comment is assigned an internal 'score' on a three point scale: 0 (no academic value), 1 (some relevance), and 2 (insightful). Preliminary analysis of thread quality in a class at Harvard University suggests that thread quality correlates with our *sustained discussion* metric[19].

3.2 Merits of Annotation Reuse

The Miller *et al.* study on the effects of "seeding annotations" on class participation shows encouraging results regarding the effectiveness of annotation reuse. The study was conducted in a Physics course at Harvard College, split into four sections of equal size. These sections included annotations from the previous offering of the class under different conditions: (1) 10 longest threads, (2) first annotation from each of the 10 longest threads, (3) 10 highest quality[1] annotations to start a thread, and (4) no comment reuse (control) [20].

Resulting discussion threads were then categorized as either: consensual, responsive, transfer, generative, or argumentative. The last two categories were of interest as they correspond to Chi's descriptions of learning patterns corresponding to the two highest levels of engagement discussed in her presentation on online learning [6].

In the study, statistically significant experimental evidence shows that prior-semester comments seeded by selecting top comments that match the *sustained discussion* criterion (discussed in the section 3.1) will "stimulate an above-average amount of discussion [...] [indicating] an above average amount of "generative interaction"" [20]. Other important results[2] include:

1. Reused comments in general, whether using the *sustained discussion* or manual

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[1] as described in Section 3.1

[2] This list summarizes relevant part of the FINDINGS section of the study [20]

quality-based metrics, seemed to receive an average of 1.16 replies compared to 0.46 replies received by regular threads ($p < 0.0001$)

2. Generative discussions emerge "four times more frequently in [reused] threads compared to [regular] threads"

3. Average thread quality in sections reusing comments (1.61) exceeds that of the control section (1.52) with $p < 0.05$

These results support our hypothesis that good comments—ones that have produced "generative interaction" in a past class offering—will tend to reliably and consistently produce generative interaction in the future. Therefore, the value of annotation reuse is to allow instructors to transplant a culture of discussion and collaboration in future class offerings. In building a content curation tool, we allow instructors to scalably cultivate higher engagement levels in their classes.

Chapter 4

NB Overview

NB allows students to read and learn from textbooks and course materials online, while also taking advantage of comments, reflections, and answers to questions that they might obtain from other students. NB differs from regular discussion forums in that discussions and comments are organized by physical location within a document, and displayed near the text, as opposed to relying on linked-hypertext and abstract categorization. NB also offers an advantage compared to other education resources such as forums and wikis by allowing the conversation to take place without leaving a document, thus maintaining a mental 'state of flow' as a student goes through the document.

In this thesis, we would like to find out what features make threads or comments *good* in terms of their impact on interactive learning. To what extent are good comments able to reliably generate interactive discussions?

4.1   Relevant Research Partnerships

As discussed in section 3.1, our candidate criteria aim to answer the above questions. These include *broad participation* and *sustained discussion* metrics based on the work of Guzdial and Turns, as well as Chi's ICAP hypothesis [11, 5]. This thesis does not include direct results to establish the reliability of these metrics in consistently producing and re-producing broad participation and sustained discussion in future

Document View   Sidebar
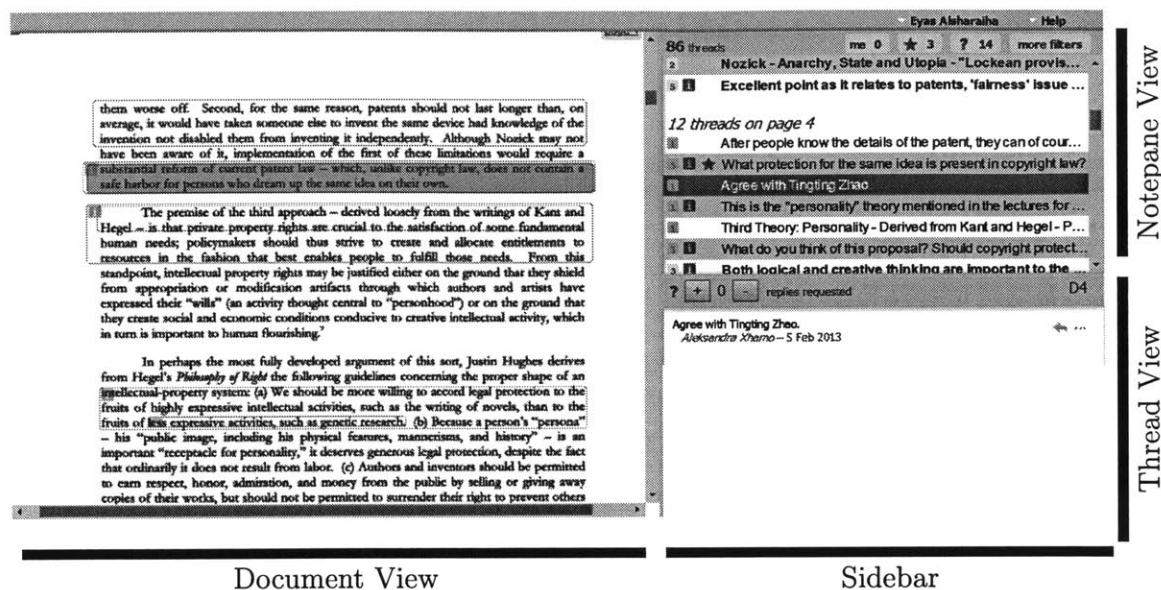
Figure 4-1: Overview of the NB user interface when viewing a document. (A) the Document View provides access to the actual document being viewed—this could be a PDF file, HTML file, or video. (B) The sidebar provides access to (1) the Notepane View, a quick way to see the list of annotations made on the current document, and (2) the thread view, which provides access to a conversation corresponding to a certain annotation.

offerings. Instead, the work of our research partners at Harvard University provides a starting point, showing encouraging and statistically significant results.

These results are outlined in the work of Miller *et al.* in [20] and in section 3.2 in the previous chapter.

4.2 Interface Overview

Figure 4-1 provides an overview of the NB user interface when viewing a document. Students accessing a document for a class are presented with this view. When interacting with the material, students tend to mainly focus on the *document view*, which presents the material with an overlay of the annotations made by other members of the class (including faculty). Clicking an annotation in the document view opens it in the sidebar's thread view, and causes it to be highlighted in both the document view itself and the notepane view.

The notepane view provides a quick way to browse through and access annotations. The notepane view provides only a list of annotations (or, *threads*) and not the individual comments or replies contained within these threads. This view provides quick labels that show, for each thread, the number of replies for each thread, whether an instructor has participated in it, whether the current student has participated in it, and whether this is a private note for the current student. Through boldface font, this view also provides a simple affordance that indicates if a certain thread contains unread comments. Clicking an annotation in the notepane view will highlight it in the document view and open its corresponding thread in the thread view. In addition, an instructor has access to *promotion*, *moderation*, and *transfer* interactions with specific threads, either through the top-bar available in the thread view when viewing a thread, or by right-clicking a thread listing in the notepane view.

4.3 Coordinate System

NB supports annotating a number of media types: PDF documents, HTML documents, and video clips. Annotations in NB are tied to a certain geographical location on a document, with an additional temporal component for video clips. NB uses a simple coordinate system to store and represent locations internally. The format used to store these annotations is described in figure 4-2.

For a **PDF document**, annotations are positioned within a given source file by a page number (p), x and y coordinates, a width (w), and a height (h).

Locations in **HTML documents** are represented by two pairs representing exact starting and ending character positions of an annotation, `start` and `end`. Each of these is a pair of a `path` and an `offset`. The `path` describes an XPATH to a given HTML DOM element and the `offset` describes the specific character offset within the given element that this annotation starts or ends at. Additionally, the overall character offset of the beginning of the annotation with respect to the entire document is stored as an additional meta-data field to facilitate the sorting of HTML annotations in the NB notepane view. This is a derived value stored for caching purposes and is

(a) PDF Positioning	(b) HTML Positioning	(c) Video Positioning
```location = { int page, int x, int y, int w, int h }```	```location = { start = { string path, int offset }, end = { string path, int offset } }```	```location = { int time, int x, int y, int w, int h }```

Figure 4-2: Pseudocode summarizing NB coordinate system for each media type

not shown in the schema presented in figure 4-2.

A **video clip**, as with PDF documents, uses x, y, w, and h to position an annotation, but, instead of a page number p, we use the time in seconds, t.

Chapter 5

Building Support for Class Sectioning Management

In online settings, we are concerned that a discussion group that is "too large", where students feel there is "nothing left to say", and when discussion groups are " too small, interesting discussion topics may be missed" [20]. These concerns present the motivation of class sectioning in NB.

To promote class-wide discussion, NB annotations are visible by default to the entire class. Students can, in addition, choose to make private comments that are visible only to themselves. Most classes do not change this default setting as it provides them with the intended experience. To describe these default sections, we say that most classes in NB are "un-sectioned"—that is, these classes do not use the NB class sectioning feature.

Class sectioning partitions thread visibility between section boundaries; students from one section cannot see posts made by students in other sections. Figure 5-1 demonstrates the different viewing privileges in a two section class.

Concerns 'over-sectioning' articulated by Miller *et al.* about missing interesting discussions in small sections are relevant when we think about sectioning [20]. While sectioning is potentially useful, it also provides additional impetus for proper faculty curation of conversations. Just as transferring discussions from a previous offering of a class holds value, transferring discussions from one section to the next could also
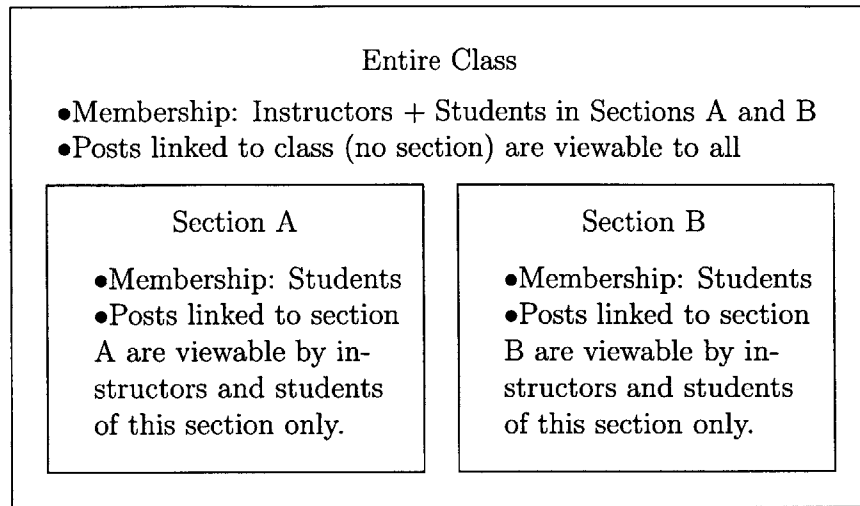
```
┌─────────────────────────────────────────────────────────────┐
│                      Entire Class                            │
│                                                              │
│  •Membership: Instructors + Students in Sections A and B     │
│  •Posts linked to class (no section) are viewable to all     │
│                                                              │
│  ┌────────────────────────┐  ┌────────────────────────┐     │
│  │       Section A         │  │       Section B         │    │
│  │                         │  │                         │    │
│  │  •Membership: Students  │  │  •Membership: Students  │    │
│  │  •Posts linked to section  │  •Posts linked to section │  │
│  │  A are viewable by in-  │  │  B are viewable by in-  │    │
│  │  structors and students │  │  structors and students │    │
│  │  of this section only.  │  │  of this section only.  │    │
│  └────────────────────────┘  └────────────────────────┘     │
└─────────────────────────────────────────────────────────────┘
```

Figure 5-1: In a class with two sections, A and B, students in Section A will be able to see posts linked to section 'A' as well as posts linked to no section. Students in section B will similarly be able to see posts linked to section 'B' and posts not corrected to any section. Instructors, who are not in any section, will be able to see all threads. Posts made by a student in a given section are automatically linked to that section.

be valuable.

5.1 Making Sectioning Accessible to Instructors

An un-sectioned class that is too large might silence students, yet students in a class with many smaller sections might miss out on illuminating discussions. Sectioned classes with proper content curation tools, therefore, may be the ideal set-up for large classes. While the NB back-end supported class sectioning for some time, this functionality was not exposed to instructors. Instead, we had to manually enable and configure sections for instructors that were interested.

Since an important aim of my thesis work is to build tools that show it is possible for instructors to easily and scalably manage their classes and class discussions, it is instrumental to build sectioning tools that are accessible to instructors. Two sectioning interactions must be supported:

1. Adding, removing, and renaming the list of available sections in a class, and
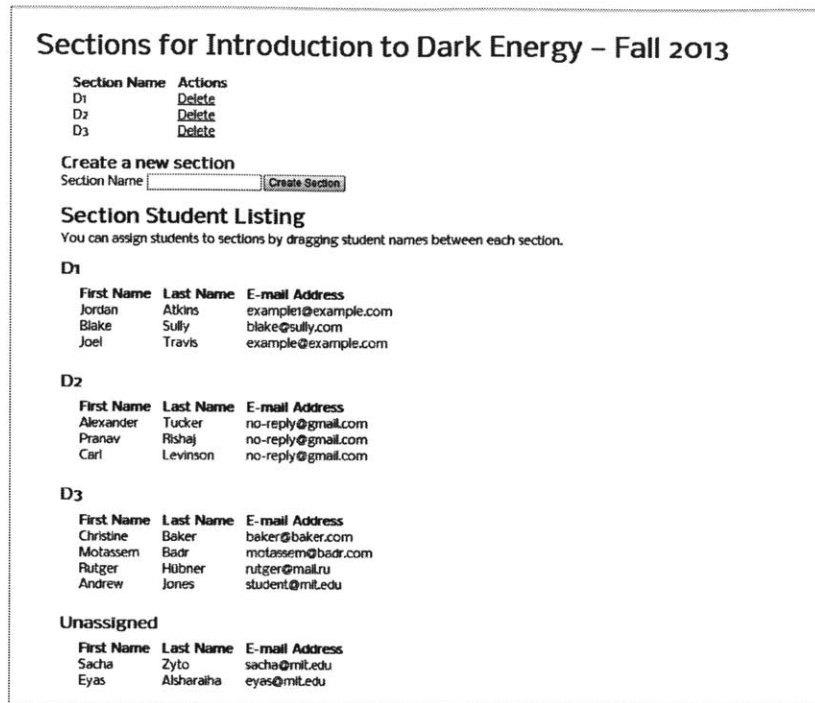
Figure 5-2: "Manage Sections" UI for an Example Class.

2. Once we are able to decide what sections we have, adding, removing, and reassigning students from section to section.

Figure 5-2 shows our sectioning UI enabling instructors to complete the two interaction types discussed above. An instructor can add sections through the CREATE A NEW SECTION control, and delete sections by selecting the DELETE action next to a particular section's row in the section listing.

This view also provides a listing of all class members, organized by section. When setting up a sectioned class for the first time, all students will be listed under the UNASSIGNED section. The UNASSIGNED section refers to members bound to no section. By figure 5-1, members bound to no section are able to view and participate in any thread regardless of its section, and new threads they start are viewable to students in all sections.

In most classes, instructors are usually unassigned to any section; they can view all interactions taking place in the class and curate them individually, and they can also make public posts or announcements that are visible to the entire class (such as

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Figure 5-3: Assigning and re-assigning users sections

D3

First Name	Last Name	E-mail Address
Christine	Baker	baker@baker.com
Motassem	Badr	motassem@badr.com
Rutger	Hübner	rutger@mail.ru
Andrew	Jones	student@mit.edu
	Sacha	

Unassigned

First Name	Last Name	E-mail Address
Sacha	Zyto	sacha@mit.edu
Eyas	Alsharaiha	eyas@mit.edu

(a) ... by dragging from "Manage Sections"

Users of Introduction to Dark Energy – Fall 2013

8 registered users

The following users have fully registered: Either by accepting an invite or by [using the class' subscribe link and confirming their email]

First Name	Last Name	Email	Role	Section	Actions	
Eyas	Alsharaiha	eyas@mit.edu	staff	D1	Delete	Remove staff status
Sacha	Zyto	sacha@mit.edu	staff	No Section	Delete	Remove staff status
-	-	nb-team@csail.mit.edu	student	D1	Delete	Add staff status
				No Section		
				D1		
				D2		
				D3		

(b) ... from users listing

a class prompt on part of a text). In other classes, where different instructors are teaching a single section solely, the instructor can be assigned to a particular section, therefore only viewing discussions that take place in that section.

Figure 5-3 shows two different ways an instructor can assign students do sections. In sub-figure 5-3a, we show how instructors can simply drag students from one section listing to another in the MANAGE SECTIONS interface. In addition, though, our user listing page has drop-down controls that enable section assignment, as shown in sub-figure 5-3b.

These tools allow faculty members to have control over class sectioning. We hope that large classes can this functionality to allow students to annotate in more crowded classroom settings without feeling overwhelmed by noise, or shut out by other students. The effect of section size on discussion should be studied further, preliminary research has been done in [20].

Chapter 6

Building a Content Curation Tool

Our content curation tool is composed of three main interaction types: *filtering,
promotion*, and *transfer* (also known as comment or annotation seeding). These interactions extend each other naturally, creating a number of workflows that empower instructors to curate online discussions in their class. These interactions extend various parts of the standard NB user interface.

6.1   Annotation Filtering

Advanced filtering options are always available to instructors from within the notepane view. In the notepane view, an instructor can access filtering options from a "more filters" button that brings up a dialog box asking the instructor to specify a set of parameters.

The filters dialog provides a number of drop-down menus connected by text, forming a complete English sentence describing what filtering criteria to use. These options are shown in figure 6-1.

These advanced filters can be intersected with each other as well as other filter toggles such as "me", "starred", "unread", or "question". Such intersection would result in the notepane view showing only the annotations which fit the selecting toggles and are among the top n or $r\%$ threads according to one of our filtering criteria.
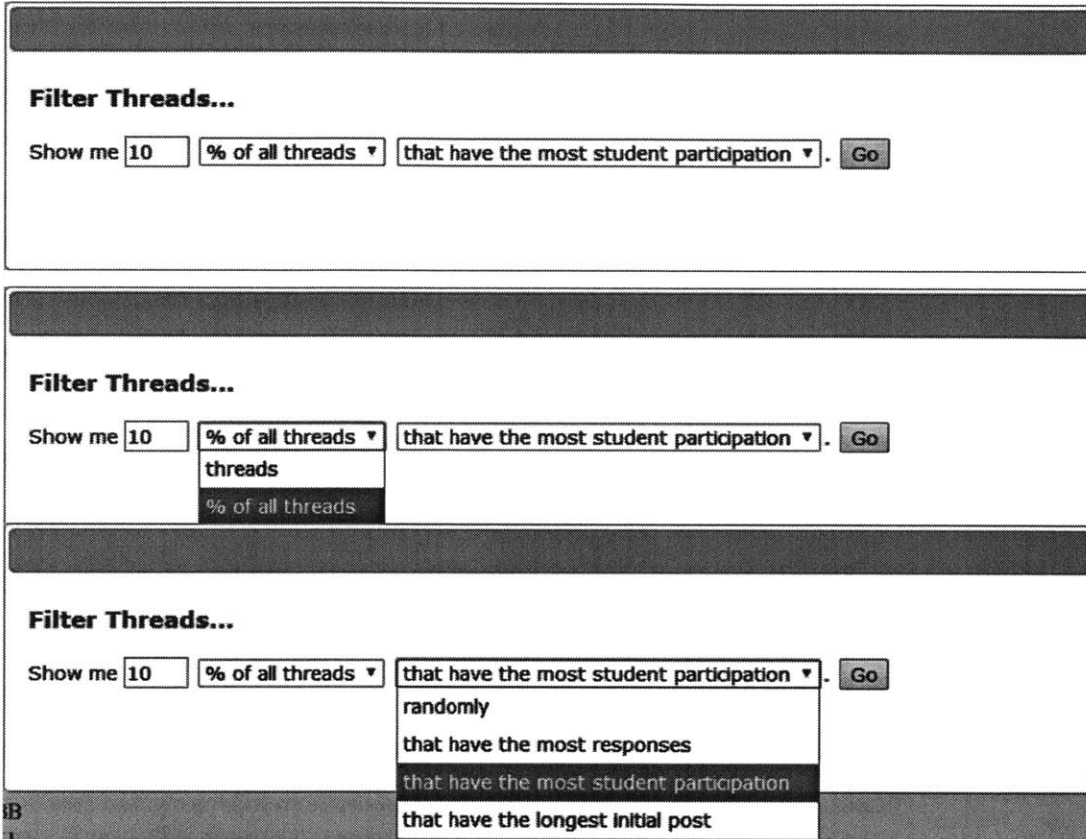
Figure 6-1: Thread filtering dialog with each drop-down menu active, demonstrating the range of filtering criteria available to instructors.
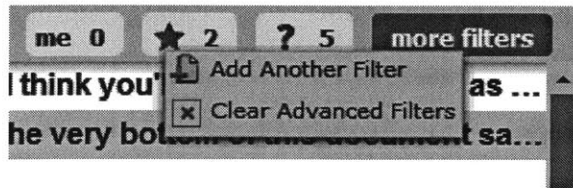

Figure 6-2: Intersecting multiple advanced filters

Filtering content using the intersection of two sets of criteria is simple. The user clicks the "more filters" button and chooses the first criterion in the intersection. After specifying the correct conditions in the dialog and hitting 'Go', the user returns to the notepane view with the "more filters" button highlighted as active. If the user clicks the "more filters" button again, a context-menu will pop up as shown in figure 6-2 prompting the user whether to clear the filter or to add another. Adding another filter will intersect the current selection with additional conditions, specified again from the filter dialog.

Our tool provides four main kinds of conditions, as shown in figure 6-1. These include:

1. Random filtering—this filter samples threads uniformly, independent of the number of comments within each thread, this filter is useful as a method of unbiased annotation sampling in large classes and MOOCs,

2. Threads with the most responses—this is the filter corresponding to the *sustained discussions* metric, providing the threads with the largest number of replies, regardless of their author,

3. Threads that have the most student participation—this is the filter corresponding to the *broad participation* metric, providing the threads with the largest number of distinct students in the class contributing to a thread, regardless of the size or number of their contributions, and

4. Threads that have the longest initial post—this filter does not correspond to any metric, and is there to allow others to begin exploring other potential correlations with comment quality.

Depending on their interests or objectives, instructors can choose to view a set number of threads or a proportion of the total threads made in the class.

Once the instructor specifies the conditions of the filtering command, the notepane view will display a restricted set of comments, corresponding to those that satisfy the set conditions. From within the notepane view, an instructor can interact with the

filtered posts in the same way as before applying the filter; an instructor can reply to a post or engage in other interactions: *promotion*, *deletion*, or *transfer*, which will be described in more detail below.

6.2   Promotion and Deletion

In the context of this thesis, *promotion* refers to elevating a discussion thread taking place in a particular section (in sectioned classes) from only being visible to that section to being visible to the entire class. There are two types of *promotions* which are of interest: (1) promoting an entire thread to the whole class for class-wide discussion, or simply (2) transferring the initial post in a thread to other sections, for each to separately discuss separately[1].

Promoting a thread to the entire class allows the whole class to witness an enlightening or illuminating discussion. Doing so is useful if the value of annotation platforms lies in the content and information they generate. In the encyclopedic register, promotion of the entire thread seems valuable. On the other hand, promoting a thread by only copying its initial post to each section allows each section to discuss the post individually. In the discussion register, promotion of the top comment seems valuable. If the thread produced by the initial post fits some criteria, then by our hypothesis the initial post may generate similarly beneficial discussions in the other sections as it did in the section where it started. Promoting threads by copying their initial post to individual sections is useful if the value of annotation platforms lies within the *process* by which the material is discussed. I suspect that both types of thread promotion will be prove to have some value in some contexts.

NB allows instructors to promote threads in two ways: either in bulk, or on a per-thread basis. We imagine the most common case for content promotion will be on a per-thread basis. This is because content promotion usually takes place as the class progresses and the instructor goes over individual comments and—once in a while—

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[1]these two also correspond to two types of *transfer* interactions which will be discussed in section 6.3

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stumbles upon a comment worthy of promotion. In that case, a complicated separate user interface for promotion would be an overkill. NB supports per-thread promotion using simple action buttons in the thread view, or right-click context menu actions in the notepane view. Bulk promotion, on the other hand, is available for high-use classes where instructors might be interested in reviewing many posts at the same time and promoting a subset of these posts.

6.2.1 Per-thread Promotion Tools

We provide access to promotion and deletion tools from two areas: For selected threads, promotion and deletion actions are exposed in the top action bar of the thread view; For any thread, including selected threads, an instructor has access to promotion and deletion tools through right-click context menu commands on individual annotations. The iteration of our tool tested by faculty members in our study in chapter 7 exposed promotion and deletion tools only through right-click context menus. Based on the results of the study, in which many users attempted selecting the threads first, we expanded out thread view to include support for such actions.

An instructor can choose to interact with any comment. This may be useful in smaller classes where the instructor could go through all threads and choose to promote or moderate particular threads. Promotion and deletion are also meant to be used with filtering; an instructor can look for a subset of threads that meet certain criteria, inspect them, and decide if she wishes to promote these discussions.

Once an instructor identifies a thread to be promoted or deleted, she can choose one of the available actions either through right clicking the item in the notepane view as shown in figure 6-3, or by selecting the item and choosing one of the actions as shown in figure 6-4.

6.2.2 Bulk Promotion Tools

When an instructor decides to promote posts in a certain document in bulk, NB triggers **bulk promote mode** in the notepane view in the current document. In bulk

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hread on page 27

| ? | Transfer First Post | t of the article: do you think rightshol.
| Transfer Entire Thread |
hreac | Promote | > | Promote thread to entire class |
| Reassign Section | > | Copy first post to each section separately |
| Delete Thread |

pidemic when people are dying is not (see a case study on AIDS runs and South African AIDS epidemic
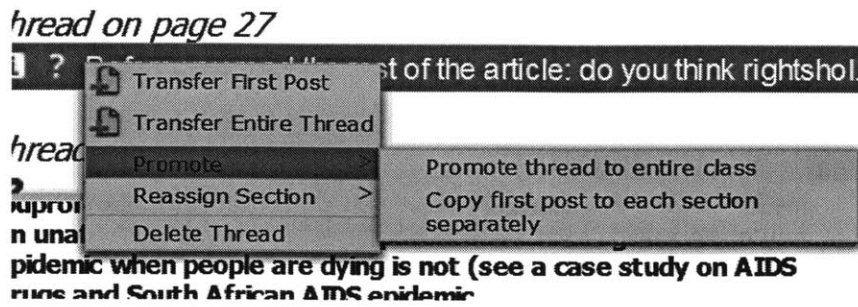
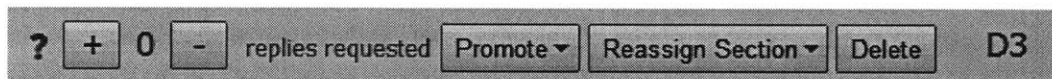Figure 6-3: Promotion and Deletion Tools through Context Menu

Figure 6-4: Promotion and Deletion Tools in Thread View

promote mode, the notepane view provides additional checkbox controls to select which threads should be promoted to other sections. The view provides two checkboxes to decide if a particular annotation should be promoted entirely (the whole thread) or if only the first post should be promoted by copying it to other sections individually. If neither checkbox is checked, then the annotation is not promoted. These checkboxes have a mutual exclusion property: both checkboxes cannot be checked at the same time (they can, however, both be unchecked). By default, both checkboxes are unchecked, signifying that no part of the comment would be promoted.

Figure 6-5 shows the basic transfer mode interface, which is nearly identical to the bulk promotion interface. Basic and advanced filters could be applied to the list of threads as is normally possible from within the notepane view, and "select all"/"select none" operations can be applied on the set of currently-filtered items. This allows the instructor to perform basic set operations to decide which posts will be promoted depending on complex compositions of criteria. Set operations will therefore allow instructors to decide which of these annotations should be promoted entirely, which should only have the initial post copied to sections, and which should not be promoted at all.

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6.2.3 Other Tools

The three bottom-most items in the context menu in figure 6-3 correspond to promotion and deletion interactions. The "Promote" option, whose sub-items are expanded, includes thread promotion as discussed earlier in this section. This option is not available in a non-sectioned class or when right-clicking a thread that has already been promoted. The "Reassign Section" option allows instructors to set a particular section that a given thread will be visible to. This is useful, for instance, if the instructor wants to target a particular section of the class with a post. Finally, the "Delete Thread" gives instructors a basic deletion power, to control the contents of the annotations shared in their classes.

6.3 Annotation Transfer

For our purposes, *annotation transfer* is distinguished from *promotion* in that transferring involves the duplication of annotations from one document to another. The second document is not necessarily in the same class offering as the first document. Simply put, promotion is transfer to other sections, and transfer is promotion to other documents.

Annotation transfer actually refers to a class of interactions that are conceptually related, not a single interaction. Just as in promotion, given a particular annotation (thread), the instructor might be interested in either (1) transferring the entire thread or discussion, or (2) transferring the initial post only. Annotation transfer is analogous to content promotion. While promotion makes posts and threads available to other sections within a document in one form or another, transfer makes posts and threads available to other documents.

6.3.1 Isolating the effect of transfer

Ideally, we would like to isolate the effect of the content of the annotation itself on class behavior, minimizing the effect of other meta-data. For both transfer schemes,

we will try to limit the effects of comment or annotation information that does not directly pertain to the content of the annotation itself:

1. **Identity of author(s).** Bogus names or names of previous students might have unintended consequences; it might introduce an atmosphere of inauthenticity to the class, or hamper students' willingness to help fellow students if they no longer believe they are actually helping out a real student. Using the identity of the faculty member might also be problematic, especially when the post being transferring is a question authored in a student's voice.

   Instead, NB makes transferred posts appear anonymously to fellow students, while still being tied to the original authors from the instructor's point of view. There is much research to be done about the impact of anonymity in online classroom settings. The effect of anonymity is unclear [26, 7] and potentially concerning, but has shown potential in online learning settings [4].

   Independently of whether anonymity holds real advantages in our contexts, we choose to keep student names anonymous mainly to avoid the disadvantages of the other options listed above.

2. **Timing of post(s).** Similarly to names, the comment time visible on each comment should be altered. Using a comment time from a year ago gives the impression of staleness and, again, might dissuade users from participating in a discussion. Instead, when transferring a single post, NB gives it the current time as if it was just posted. When transferring a thread, NB gives the *most recent* post in the thread the current time, and gives every other thread a corresponding time that respects the ordering and preserves the magnitude of the previous time deltas.

6.3.2   Transfer use cases

When transferring annotations to a new offering, an instructor might be interested in either using identical materials, or adapting old annotations to new or modified texts/materials.

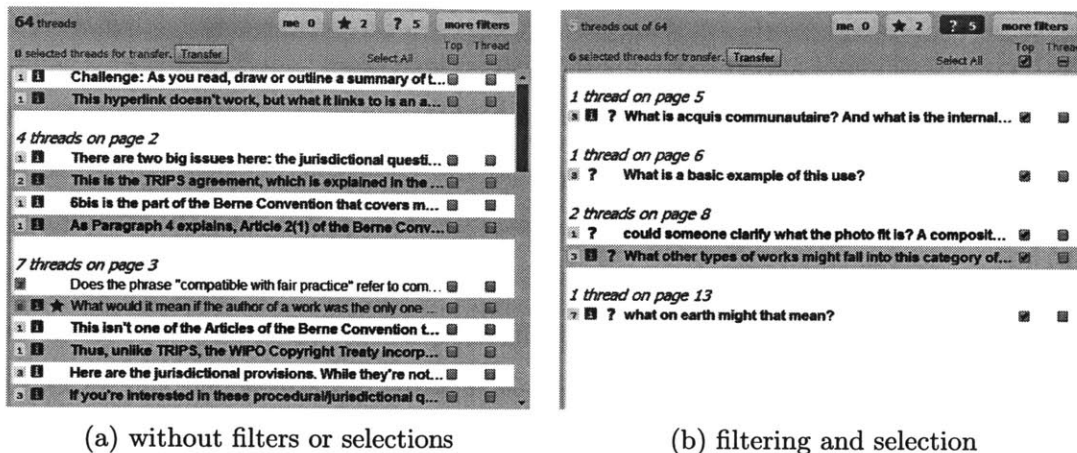(a) without filters or selections   (b) filtering and selection

Figure 6-5: The NB Notepane View in Transfer Mode

When reusing identical materials for a future offering, our existing annotations can be transferred to the new class by using the same coordinates (described in figure 4-2 on page 36) and simply changing the source document to point to the new one. If an instructor is using modified texts or materials, copying annotations over using the same coordinate system leads to annotations that are misplaced on the content. The page numbers or locations of text might be different in the case of a PDF document, or the length of the video in the case of a clip, or the structure of the HTML document. As we lack an automated tool that determines how to convert old locations to new locations given two versions of a text, we must ask the instructor to place the transferred annotations manually in the new document.

6.3.3 Annotation Transfer for identical documents

When an instructor decides to copy a document from a previous class offering into a new location (in a new folder or a new class altogether), she will be presented with a link to start selecting annotations to transfer over to the newly created file. Clicking that link will open the *old* document in NB, and triggers **transfer mode** in the notepane view.

Transfer mode is very similar the bulk promotion mode discussed in section 6.2.2. The notepane view still provides checkbox controls to select which threads should be
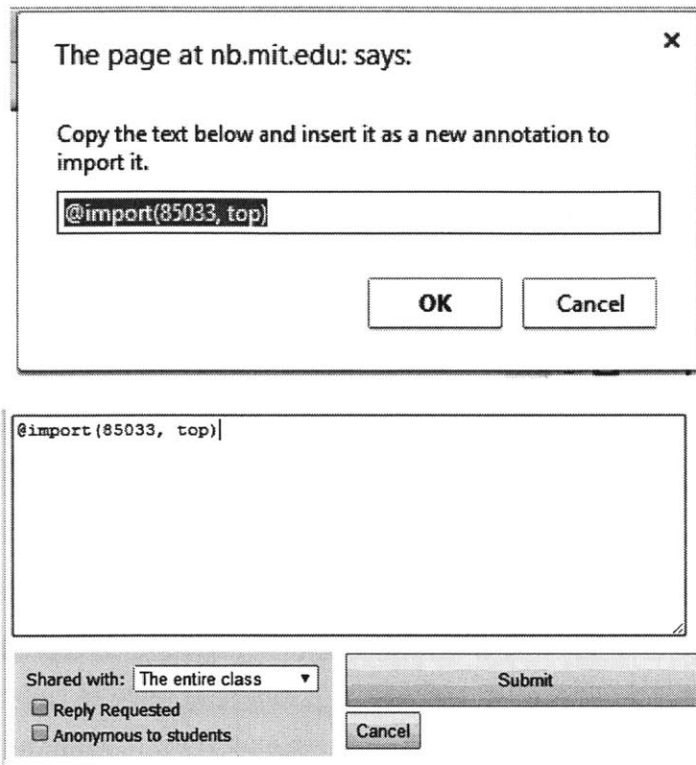
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Figure 6-6: Manual Annotation Transfer through copy and paste

transferred to the newly-created document. The two checkboxes decide if a particular annotation should be transferred entirely (the whole thread) or if only the first post should be transferred. Again, when neither checkbox is checked (which is the default state), then no part of the annotation is transferred.

Figure 6-5 shows the notepane view in transfer mode.

6.3.4 Annotation Transfer for modified documents: Current Solution

We were prompted early on to implement tools supporting annotation transfer for manual documents. Our research partners at Harvard had agreed to conduct the annotation transfer experiments presented in [20], but decided to use an updated version of the text which did not preserve geographic locations of the text. Thus, we needed to create a transfer tool that allowed an experienced instructor to manually
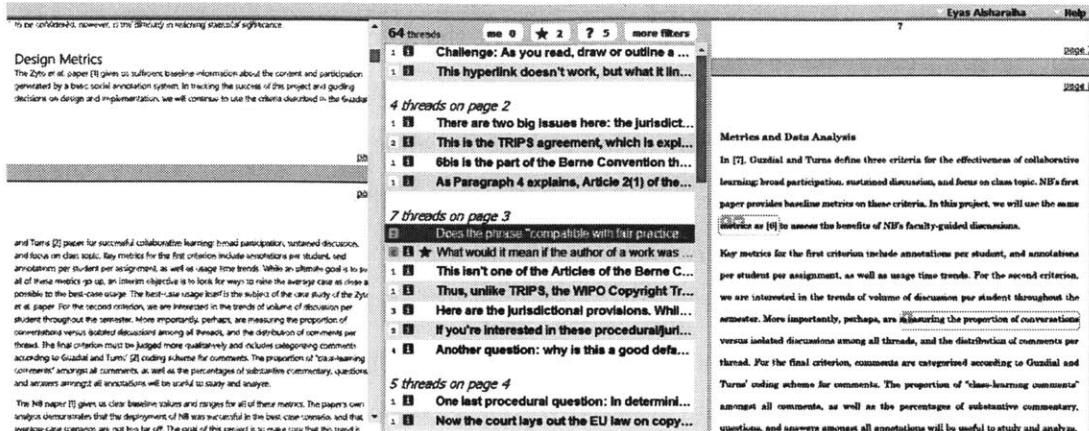
Figure 6-7: Manual Placement Mode: The Second Step in Annotation Transfer for modified documents

decide which threads to transfer and where to place them in the resulting document.

The manual transfer tools are accessed through the per-thread context-menu as shown in figure 6-3 on page 46. Two manual transfer options exist: to transfer the first post, or to transfer the entire thread. Selecting either option would present a unique snippet that the instructor must copy to her clipboard. The instructor is then free to create an annotation in any place on any document, and paste the snippet as the body of the comment. When the annotation is submitted, the snippet is replaced by either the first post or the entire thread, depending on which option was selected. This process is illustrated in figure 6-6.

6.3.5 Annotation Transfer for modified documents: Proposed Design

Here, I propose a design that guides the user through two separate steps: selection for transfer, and placement. This proposed design removes the manual copy and paste process, instead directing the instructor on a two-step process through a guided wizard.

When an instructor uploads a file, she is presented with a prompt asking if she would like to import annotations from another document. If she answers yes, she will first be prompted to select a document from which to transfer annotations from. At

this point, NB will launch the *old* document in the same transfer mode as the one discussed in Section 6.3.3 and shown in figure 6-5. The instructor will be able to filter threads, select to import the entire thread for some annotation, or the top post only for another. Once the "Transfer" button is pressed, however, we move to a new interface: the **placement page**, shown in figure 6-7.

In the transfer view, the user sees the old document on the left and the new document on the right. The notepane view is now in the middle and includes only threads selected in the previous step. Clicking a thread in the notepane view will cause the old document to scroll to the location that includes it. If the thread has already been placed, clicking it will also cause the new document to scroll to its position.

In the old document, dragging across the document to insert annotations does not work. In the new document, dragging is disabled if no thread is selected. If a thread is selected, drawing annotations places the selected thread in a certain location in the new document. If the annotation is already placed in the new document, this will change its location.

Chapter 7

Faculty Interviews

A number ($N = 8$) of faculty members from around the world were interviewed during
and after the implementation of the content curation tools to gather feedback about
the direction and effectiveness of the design I have implemented. In these interviews,
I studied three main areas: (1) verifying user interface usability and learnability, (2)
reducing unexpected behavior caused by mismatch with the conceptual model, and
(3) confirming interest in our choice of metrics.

The interviews were started with a general overview of the problem at hand. The
interviews went on to user testing of a number of areas of content curation. Content
promotion and moderation was overviewed and showcased, and a number of questions
were asked to the faculty to gauge impedance mismatch between the object model
and the user's conceptual model. Examples of questions include: "This thread is
assigned to section 1, what would change if we promote it to the entire class, in terms
of who can see each individual comment in this thread?"

The interviews also included a more traditional user study, which focused mainly
on file duplication and annotation transfer. In this study, faculty members who have
used NB in the past were asked to look over the NB view of one of their past PDF
documents, duplicate it to a new class, and transfer a number of annotations over.
Some detailed tasks were given to faculty members as well. These tasks, in addition to
the other questions asked in the annotation transfer portion of the study, are outlined
in Appendix A.

7.1 General Observations

In the iteration we tested, one recurring theme throughout the interviews was the fact that the Web in general does not afford right-click context menu interactions. While users of traditional desktop applications would have no problem reaching additional tasks corresponding to a particular item by right-clicking it and expecting a context menu, those same users see no affordance of right-clicking for additional actions when they are using a web application. As such, many of the additional actions introduced in NB's content curation tools were hindered by discoverability issues of right-click context menu items in the Web. This includes content promotion and moderation, manual per-comment comment transfer, and file duplication. Instead, many users selected threads via left-click and expected these actions to show up in the expanded thread view.

Once instructors located the context-menu commands, however, they found that using them was rather straightforward.

As a result , we have since added promotion and deletion controls for individual threads in the expanded thread view on the top action bar. For file duplication, the problem is alleviated by an "Actions" button that gives access to the same context menu items via left click.

7.2 Import, Export, and Content Promotion

7.2.1 User Interface Issues

Some of the faculty members found manual annotation transfer confusing. It was not clear to them that these users had to copy the selection in the pop-up manually and paste. Manual comment duplication is a temporary feature; to be replaced by an automated transfer mechanism is created for differing document version (or differing document types, for that matter). Experiences with manual transfer highlight the importance of a more guided manual transfer interface. Once again right-clicking was a barrier to discovery, the lack of an "actions" button in the notepane view meant

that there was no obvious way to alleviate this.

7.2.2   Sectioning & Content Promotion

Another important aspect of our promotion and moderation tools is sectioning management. Sectioning management involves allowing certain threads to be promoted to all sections or part of them to be copied over to individual sections. Here, we found that users previously familiar with sectioning had no problem with content promotion. Section reassignment and promotion to the entire class was simple and conformed with their conceptual model of how the system worked. Other, more complicated sectioning options, such as promoting a post by copying it to other sections to discuss individually, was understood immediately as well—users report that the name of the action was self-descriptive.

We also tested faculty members' conceptual model. We presented a number of users: User 1, User 2, and User 3, who are in sections 1, 2, and 3, respectively, in addition to an instructor who is not bound to a section. For a number of comments in a simple class, we asked them to whom were they visible, to whom were their responses visible, and how these visibility rules would change if different actions were applied.

For users familiar with sectioning, their conceptual model of sections and of how promotion works, correspond with the object model. Faculty members in general, however, are not very familiar with class sectioning. For faculty members less familiar with sectioning, we found that their conceptual model of how sections worked did not correspond to how the object model worked, leading to a mismatch in behavior expectations for our promotion tools that pertained to class sectioning.

7.3   File Duplication and Comment Transfer

In our initial file duplication wizards, users often forgot to specify a target file name which resulted in an error. In file managers, file copying usually implies duplicating files over while keeping their current names intact. Therefore, our file duplication

dialog was modified so that it pre-populates the file name field with the selected file's name.

The file's location picker, on the other hand, was immediately usable and straight-forward. Faculty members did not have any problems figuring out how to duplicate a file to another class or sub-folder, and (correctly) expected to be able to copy a file to a different folder in the same class.

In the comment transfer interface, some faculty members had trouble locating the "Select All" checkbox. Some attempted to hit the "Select All" label instead of the checkboxes themselves. While select-all boxes in tables corresponding to entire columns is a common UI concept, it seems that users don't expect it in some web applications like NB. Another issue is the default styling of text boxes in Google Chrome—the browser of choice for the user study—since it overrides native system styles for basic input elements, including buttons and checkboxes.

Once users located and tried the "Select All" checkboxes, however, a number of the more intricate concepts were easy to grasp: users had no problem understanding mutual exclusion between two checkboxes, and how that interacts with filtering and "Select All". Users also understood how to perform basic set operations on threads to transfer a subset of comments over. For most interactions, users reported that the resulting behavior was what they expected.

7.4 Metrics and Filters

Faculty members were interested in filters at first, and seemed to like the "Student Participation" and "Number of Responses" filters. The faculty members interviewed reported the correct search and selection criteria when asked to elaborate on their conceptual models. That said, many subjects assumed that, once filtering takes place, threads in the notepane view will be sorted by the search criterion in descending order. In our current iteration of the content curation tool, this is not the case—instead, threads are still sorted according to their geographic location on the document.

Many faculty view these filters as an effective way of gauging class performance

during the course of an offering, and a useful metric for promotion. Some faculty members reiterated that they are more interested in manually going through all annotations and selecting interesting ones, rather than relying on these metrics when reusing comments from previous offerings. Some faculty members indicated that these filters and metrics are useful "optimizations" that allow them to make sure certain comments are included. However, they are neither necessary nor sufficient conditions to make a comment an "interesting" one that should be transferred.

Our research partners at Harvard, on the other hand, are interested in and committed to rely exclusively on these metrics to study their impact. While we agree that these metrics are probably neither a necessary nor a sufficient condition for a "good" comment, we believe they are a close approximation that might be useful in larger classroom settings. Through the planned future work with Miller, Mazur, *et al.*, we will gather more data about the effectiveness of these metrics.

As part of the faculty interviews, we asked our faculty subjects for other metrics that they might be interested in seeing. Some faculty members were interested in a number of additional filtering tools for the purposes of class analytics and grading such as filtering a particular document's threads down to the set of comments authored by particular student. As far as comment quality assessment however, faculty members indicated that the current metrics seemed sufficient.

Chapter 8

Conclusion

The content curation tools discussed offer the building blocks for further interesting research on collaborative learning online, albeit with some limitations. Given past related works, the metrics developed provide interesting insights on how to promote collaborative learning in the classroom. In the era of MOOCs and classroom scalability concerns, further work is sorely needed so that faculty can continue to guide conversations and promote collaborative learning as class size increases. Annotation reuse may be an appropriate solution to this problem.

8.1 Recommendations for Future Work

This work highlights a number of areas where additional exploration of comment reuse is necessary. For instance, the effects of fullness versus vacuity (feeling there is nothing left to add, versus lack of encouragement or inspiration to comment) on the collaborative atmosphere of a class should be studied. Further, the potential of seeded comments leading to other (separate) discussions to spring up should be isolated and evaluated. Separately, the effect of comment seeding on the culture, tone, and atmosphere of a class is also interesting, especially in online settings: would a particular set of comments encourage students to be more inquisitive, lower the barrier to ask questions, encourage politeness, and otherwise transform the class culture?

As we study various aspects of comment reuse and content promotion, qualitative

evaluation of comments produced as replies to seeded comments, as done by Miller *et al.*, is crucial [20].

The content curation tool itself is also in need of further iterations. For instance, supporting a more asynchronous mode where faculty could choose content to transfer to other documents over the course of multiple browser sessions—possibly throughout the course of an entire offering—might be relevant. Why manually comb through many threads and comments at the end of a class if an instructor has been going over them incrementally? NB functionality such as "starring" serves as an interesting template for future work.

Adding support for a new comment transfer tool that works across changed documents (and possibly also different document types) would also be a welcome addition.

For analytics, as well as content curation during the course of a class, faculty members might be interested in filter options that intersect existing filters with the set of *recent* posts. For instance, it would be very useful to be able to filter out the 10 most active *recently started threads*, or *recently active threads*. This would be especially useful for content curation in large classes with many sections such as MOOCs.

Appendix A

NB Annotation Transfer User Study

The purpose of this study is to evaluate the effectiveness of the newly designed NB Annotation Reuse UI. You'll be given instructions on how to launch the interface, and a few tasks to complete. Please think out loud as you complete these tasks, and express any struggles you might experience along the way. There are no wrong answers—any difficulty you face could be a difficulty faced by future users.

The NB Annotation Reuse Interface   The interface is triggered by duplicating an NB document (into another class or simply another folder) and choosing to transfer annotations. The interface is meant to allow you to select a number of posts based on different criteria, as well as manually, and choose to move them over.

Tasks:

1. Choose one of your files to duplicate somewhere with a new name, and begin transferring annotations. (*this is intentionally a guiding question*)

2. Look over some of the comments and choose to transfer a few that catch your attention.

3. Transfer the 5 threads that generated the most replies.

   (a) If guidance is needed: What do you think is the difference between the

two checkboxes?

(b) Explain that we want the entire threads transferred.

4. Look at the 5% of threads that generated the largest number of student responses.

5. For all of these threads, transfer the top post only.

(a) What do you think happens if there is an overlap with previous selections? What do you think will happen with previously selected items?

6. Look over the 5 longest initial posts.

7. Make sure none of these posts are transferred.

8. Look over all posts again, and add the entire thread of another one of them.

9. At this point you can complete the process. In your conceptual model, are the annotations transferred already? Do you think you need to do anything else?

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