Anchored Discussion as a Source of Feedback for Lecturers

by

Velian Pandeliev

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Graduate Department of Computer Science
University of Toronto

Abstract

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Velian Pandeliev
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Graduate Department of Computer Science
University of Toronto
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Student feedback is an important trigger for changes in teaching practice in higher education.[29] Educators are constantly evaluating their performance in a course, gathering, interpreting, and acting on direct or indirect feedback from students. However, a survey of existing sources of feedback in computer science lecture courses reveals that they are sparse on contextual details, are not broadly representative, or arrive too late to facilitate timely change.

Student feedback is traditionally thought of as a learner-instructor interaction [3] in which the student conveys information directly or indirectly about their experience with a course to the lecturer. However, many aspects of student learning behaviour fall outside of that designation and information about them is difficult to access by lecturers in traditional classroom settings as they happen without the lecturer's involvement. As more student activities transition to the digital realm, data from additional learner-learner and learner-material interaction sources[24] is becoming available alongside learner-instructor interactions to inform teaching decisions and to aid in course monitoring.

Social annotation combines peer discussion and document annotation and demonstrates great benefits to improving learning outcomes [27], but it has not been thoroughly evaluated for its suitability to providing feedback to lecturers. An encouraging study by Zyto et al. [44] hinted that an open-source anchored discussion board called Nota Bene could be used to inform teaching changes, but did not describe or evaluate that process, leaving a tempting research gap.

In this paper I propose to use Nota Bene as a testing platform in a case study to investigate how student feedback given in anchored and unanchored discussion boards informs changes in teaching practice in lecture-based classes in computer science as a first step towards building an anchored discussion board optimized for feedback collection that can support educators in interpreting feedback and acting on it in a timely and data-supported manner.

Contents

Chapter 1

Introduction

Student feedback is an important trigger for changes in teaching practice in higher education.[29] Lecturers interpret direct and indirect feedback to inform these changes, deciding whether a significant issue has been identified, how their class is affected, and whether they should change their teaching. Educators are eager to receive formative feedback that helps them improve their students' experience.[2] However, most existing sources of feedback are sparse on contextual details, are not broadly representative, or arrive too late to facilitate timely change.

As more and more learning activities are performed in the digital realm, new aspects of the learning process will become available as potential sources of actionable feedback. I am interested in two sources in particular: peer discussion and document annotation. Their combination has demonstrated some potential in informing teaching practice[44] but remains unexplored and poorly understood as such.

In Chapter 2, I describe the types of feedback used by computer science educators in lecture-based classes, noting that they are all products of learner-instructor interactions[3]. I outline some of their shortcomings and I identify two additional potential sources of feedback data: peer discussion (learner-learner interaction) and document annotation (learner-material interaction). [24]

Chapter 3 is devoted to tracing the emergence of anchored discussion boards and their advantages over their unanchored versions, to describing a current-generation open source anchored discussion board called Nota Bene[44], and to demonstrating its suitability as a platform for my initial exploration and as the base for developing new feedback gathering and interpretation techniques.

In Chapter 4 I describe a contrastive case study of lecture-based courses in computer science to explore the question: ***"How does student feedback given in anchored and unanchored discussion boards inform changes in teaching practice in lecture-based classes in computer science?"***.

The results of this study, combined with a survey of student feedback attitudes and behaviour, will be used to inform modifications of an anchored discussion board to make receiving and interpreting feedback less time-consuming for lecturers. The modified system will be evaluated in a class deployment. A tentative Ph.D timeline and next steps follow as Appendix A.

Chapter 2

Feedback

Education literature (e.g., [29, 41, 19]) is unanimous in its expectation that educators' teaching practices will change from term to term and from module to module in order to better address the needs of students. Such changes are undoubtedly influenced by the characteristics of the lecturer's institution[18], by her interactions with her peers[3] and by her own motivations, values and attitudes towards new ideas [22]. However, since the overarching purpose of altering teaching practice is to improve learning outcomes and engagement for students, I will focus on understanding how student feedback during and after each course offering influences these changes.

As Huxham et al. summarize, *"[o]btaining feedback from students is an essential requirement of reflective teaching, allowing teachers to refine their practice and to develop as professionals."* [19] Educators need to understand how students are engaging with the course, how they respond to teaching practices and materials, and how these elements can be improved for current or future cohorts. This is particularly applicable to computer science education, which is a dynamic field greatly concerned with student retention and diversity.[3]

In a seminal 1989 classification, Moore [24] identified three types of interaction in education: **learner-content** (intellectually engaging with content in order to improve understanding), **learner-instructor** (communicating with a domain expert who has prepared learning material) and **learner-learner** (collaborating with peers in pursuit of learning).

The traditional definition of *"student feedback"* falls under a **learner-instructor** exchange in which the student transmits information to the educator, which is then used to inform teaching practice. Most established ways of gathering student feedback conform to this definition, mostly because the other two aspects of what students do in the course of learning has historically been inaccessible to educators. With the emergence of new educational technologies, **learner-learner** and **learner-material** interaction become viable sources of feedback.

In this chapter, I will first establish why lecturers need student feedback and how they translate it to changes in teaching practice. I will then survey the established **learner-instructor** means of obtaining feedback in computer science education. Although many of them are also applicable to blended learning environments, distance education and massive open online courses (MOOCs), I will focus on lecture-based instruction. I will also identify some of the collection and interpretation challenges inherent to these forms of feedback. Finally, I will discuss two potential sources of feedback that may alleviate some of these challenges.

2.1 Feedback and teaching practice

Broadly, feedback obtained from students has one of three purposes: to help teachers improve their teaching, to inform hiring decisions and provide accountability to managers, and to support future cohorts when choosing courses. [29] Penny describes feedback collection as *"one of the most sensitive, divisive and political [issues] in education"* [29] due to the tension between summative feedback meant to evaluate educators and formative feedback that nurtures ongoing reflective teaching and improvement.

Arthur et al. [2] identify significant issues with soliciting student feedback for summative purposes. Students derive no benefits from rating their educator's performance after the fact as it solely benefits future cohorts. Educators in turn feel that students may not be qualified to judge their performance, and that institutional pressure to perform, or to appear to perform, in response to such feedback is at odds with their core professional principles.

Although I recognize the decision-making needs of institutions and future cohorts, I will focus solely on using student feedback as a formative tool for improving teaching practice. This would enable students to shape their own learning experience and give educators a chance to react in good faith to any teaching challenges that arise.

In a survey of MOOC course instructors, Stephens-Martinez et al. [35] identified nine course monitoring goals for educators that covered five aspects of their students' experience:

- **Challenge and difficulty:** gauging if course difficulty suitable to the cohort, posing appropriately challenging assessments and identifying the most difficult part of the course.
- **Struggling students:** finding and supporting students in difficulty.
- **Student engagement:** identifying topics students found the most or the least interesting
- **Presentation:** finding ways to improve how a topic is taught or addressing problems with a document or assignment
- **Teaching assistant effectiveness:** understanding how well TAs are meeting the needs of students

To evaluate how well they are meeting these goals, educators monitor raw data from a wide range of sources, including performance, perceived engagement, student questions and suggestions.

2.1.1 Data gathering

The first requirement of successful course monitoring is the availability of relevant student feedback data. Some forms of data such as student grades are automatically stored, but much of it is transient and difficult to capture. Additional effort must be made to obtain or retain data from uncollected learning activities, live discussions and in-class behaviour. As more student activities are digitally tracked and recorded, more and richer sources of monitoring data become available to educators.

2.1.2 Interpretation

Once student feedback is available, educators must determine if any of it indicates a potential reason to change their teaching. This can be difficult if there is an overwhelming amount of data [35], if the data is not well suited to course monitoring or if educators lack the time or training to engage with it.

In interpreting student feedback, educators have to determine if they have uncovered a potential issue, how serious it is, and whether they should act to implement a change. Arthur [2] interviewed eight postsecondary educators, who reported both instances of making changes as a result of student feedback and instances of judging proposed changes to be inappropriate. Lecturers ignored an issue that only one student had reported, kept teaching a concept students identified as difficult because it was essential for students to learn, overruled student requests for changes that they knew would put them at a disadvantage in the workplace, and dismissed feedback that seemed to not align with the facts.

2.1.3 Action

Once they have decided to act, educators can find existing solutions to address the issue or create new interventions as required. Fossati and Guzdial [13] found a growing body of resources and potential solutions for educators in computer science.

2.1.4 Evaluation

After an intervention is deployed, its success must be evaluated. Fossati and Guzdial's participants reported both successful and failed interventions. [13] Evaluation of teaching changes is a cyclical process that requires gathering and interpreting a new batch of performance data and student feedback.

2.2 Learner-instructor feedback

Barker and Gruning [3] interviewed 66 computer science lecturers in order to determine what sources of student feedback they used and how they made teaching changes and decisions in their classrooms. Their participants cited student feedback as *"an important factor [and] motivator in decisions about changing teaching practices"* [3] and they actively sought sources of feedback in order to improve learning outcomes and to promote greater student engagement in their classes.

The study identified four primary types of student feedback sources that lecturers used to make changes in teaching practice: formalized evaluations, direct requests from students, feedback inferred from performance, and non-verbal behaviour.[3] All four types were forms of **learner-instructor** interaction: students gave feedback to the lecturer, they submitted work to the lecturer, or they acted and reacted in the lecturer's presence.

The first two types are forms of ***direct feedback***: students are contributing their opinions and suggestions *about* how the course is taught, either in a format **facilitated** by the lecturer through formalized evaluations or discussions, or directly **volunteered** without prompting or structure.

Feedback inferred from **performance** is a form of ***indirect feedback*** that asks the students to demonstrate understanding or application of the material to the lecturer, who then interprets the results. Student performance may be graded or ungraded. Finally, Barker and Gruning's *"non-verbal behaviour"* refers to the subjective impressions a lecturer obtains from students' demeanour in their classroom. Another form of indirect feedback, these impressions are readily available to lecturers in brick-and-mortar classrooms, but they are by far not the only form of student **behaviour** that may be useful in informing teaching practice. Table 2.1 details the feedback sources discussed in this section as classified in the above categories.

Direct feedback	
Facilitated	***Volunteered***
Student evaluations of teaching Custom feedback forms Facilitated discussion	Student-volunteered feedback
Indirect feedback	
From performance	***From behaviour***
Comprehension checks Graded performance	In-class impressions In-class reflection Student questions

Table 2.1: Sources of learner-instructor feedback

2.2.1 Direct facilitated feedback

Lecturers solicit feedback from students about their teaching using various tools and techniques.

Student evaluations of teaching

Student evaluations of teaching (SET) are the most common and most widely studied means of obtaining student feedback in higher education [34]. A SET form consists of a battery of numerical scales with an optional field for additional comments that provides a summative assessment of a lecturer or a course. Students fill out SETs at the end of the term, about the course as a whole, and with the tacit understanding that their feedback will not impact their own learning experience. SET results are primarily used by institutions for accountability and to inform staffing decisions.

SET assessments may be confounded by class size, student experience, lecturer appearance, grade expectations, or enjoyment [34]. SETs have also been criticized [2] for attempting to reductively measure the performance of educators, rather than yielding actionable feedback they can use to improve, and for generally arriving too late to be informative.

Despite these shortcomings, SETs have two main advantages: *"they provide an opportunity to obtain feedback from the entire population of students; and they document the experiences of the student population in a more or less systematic way"* [30], which enables comparison across cohorts.

While lecturers in Barker and Gruning's study were able to extract an overall sense of their performance from SET results, they found closed-ended ratings were too abstract to recommend teaching changes and deemed students' freeform comments more informative [3]. This led to a tendency to overestimate how representative individual comments were of the class as a whole, with lecturers sometimes making course-wide teaching changes based on a comment from a single student.

Custom feedback forms

Some lecturers, frustrated by the rigidity of SETs and seeking greater detail or more targeted questions in their end-of-term evaluations, reported deploying custom evaluation forms that yielded more actionable feedback. [3]

Facilitated discussion

Lecturers organize discussions with students about their teaching so they can solicit more open-ended feedback and ask for follow-up details about what they hear. While SETs and evaluation forms tend to be anonymous, facilitated discussions with the lecturer can be daunting for students since feedback can be traced back to them. [3] To alleviate this challenge, teaching assistants may be asked to gather feedback instead, reducing the perceived power imbalance.

Finelli et al. [12] proposed having an impartial facilitator conduct a midterm feedback survey or discussion, work on a strategy for improvement with the lecturer, then assess its effectiveness with a follow-up survey. Unlike an SET, this method extends some of the benefits of improvement to the students offering the feedback. The facilitator can probe for details the lecturer may not have noticed and students would feel more comfortable opening up to an impartial third party.

Witt [41] suggested electing student representatives to aggregate feedback from the class and pass it on to the lecturer or to a facilitator at set intervals. This technique achieves a reasonable amount of consensus, although recommendations tend to lack detail and to arrive too late to inform concept-level challenges.

2.2.2 Direct volunteered feedback

Students will sometimes bring requests or recommendations about the course directly to the lecturer without being prompted. When students' identities are known, they are reluctant to criticize and some are tempted to offer positive feedback as a means of currying favour. [3] Feedback volunteered anonymously may be less thoughtful or unnecessarily critical, although students are very rarely uncivil. Tucker [39] analyzed over 30000 student comments from Australian post-secondary feedback surveys and found fewer than 0.2% to be abusive or unprofessional.

Unsolicited feedback may be affected by students' grades, social factors or personal preferences, and it does not generalize well since it lacks the structure of a constructive feedback instrument. It is also difficult to interpret and unpredictable in quantity.

While direct feedback may sound more immediately actionable (e.g., *"This slide is too confusing. Please add more examples."*), students are neither equipped nor expected to be experts in pedagogical practice, and all feedback should be evaluated through the lens of the educator's experience and training.

2.2.3 Indirect feedback inferred from performance

Student performance refers to whether students have achieved their learning goals for a particular module. Although there is a great deal of variety in academic evaluation, two types are notable in their relationship to student feedback:

Comprehension checks

Immediate in-class comprehension of a concept can be gauged with an in-class testing question. Although polls may be as informal as students raising their hands to indicate the correct answer, technical solutions exist for larger classes.

Student Response Systems (SRS), colloquially known as *"clickers"*, are simple devices with multiple choice response options. Student responses are collected, aggregated and presented to the educator and

often to the entire class. Feedback obtained through clickers is given at the right time, situated in the right context, and by a countable portion of the class [38], but it is typically limited to one of a few simple options, and the onus is on the educator to devise meaningful monitoring questions and to interpret the students' responses.

Graded performance

Student grades on assignments, projects, and tests are a source of passively given instructional feedback that is generalizable and quantitative by default. This method yields good consensus without additional effort as the entire class contributes data, but it can only identify what concepts students had trouble with, not why performance faltered or how to improve teaching. [3] Teasing out the underlying causes may be difficult, and it may be too late to enact change if the evaluated topic is not revisited.

2.2.4 Indirect feedback inferred from behaviour

When measuring performance, lecturers can understand what students know and what they struggle with, but they are glimpsing the end result of a process that began with the first introduction of a concept and likely included steps that the lecturer was not privy to. Inferring from behaviour refers to lecturers' attempts to glimpse how students make sense of concepts and how they interact with teaching materials.

Nonverbal behaviour

The demeanour of students in a lecturer's classroom as new material is being taught provides an immediate if vague sense of how engaged students are and whether they are paying attention. Lecturers can use this form of indirect feedback to adjust pacing or strategies. However, even this general sense of understanding and engagement is difficult to interpret correctly. [3] Extracting meaningful conclusions about what students are thinking in that moment or whether material is being delivered effectively is highly unreliable, even for seasoned educators.

To aid in interpreting in-class moods and affect, Dewi et al. [10] created a system that automatically captures student facial expressions during a live lecture, analyzes them for affect and make recommendations to lecturers on improving the mood in the class. Unfortunately, the system had some difficulties capturing affective data reliably and the granularity of the given feedback was extremely coarse.

In-class reflection

Lecturers may augment their limited, subjective impressions of student engagement with a reflection task that asks the class to rate their understanding of the material or to identify a concept they are struggling with. Soreanu and Saucan [33] proposed an intermittent probe that asks students to rate the current concept's difficulty and their understanding of it.

Educators have also used tools such as the *"Muddy cards"* technique: at the end of lecture, each student answers a version of the question, *"What was the muddiest point in the lecture?"* [25]. Students' answers reveal unresolved confusion [14] about the current lecture and lecturers have a chance to adjust their teaching to address that confusion for the next one.

Note that in in-class reflections, students share their perceptions of a concept's difficulty or how clear it seems to them. They are not asked to comment on how material is taught (as they would be in a

direct feedback discussion), and they are not objectively evaluated on their understanding (like with a comprehension check).

Student questions

The questions students ask lecturers may reveal what they are struggling with in a timely and targeted manner before they are evaluated on it. As with all forms of volunteered feedback, the onus is on students to come forward, so many questions may never reach the lecturer. At the same time, it may be difficult to gauge whether the ones students do ask apply to anyone else in the class.

Questions asked in person during class or in office hours may have limited potential in informing teaching as they require additional lecturer effort to remember or record them for later interpretation. They also tend to come from the more socially comfortable students in the group, who may not necessarily be the ones experiencing the greatest difficulties.

Online discussion boards (which I discuss later in the chapter) can alleviate many of these challenges: they are permanent, students can ask questions anytime, and introverted students can participate on more equal footing. [8]

2.2.5 Challenges

Lecturers consistently struggle with three major challenges of gathering and interpreting feedback:

Timeliness

Formative feedback should arrive with enough lead time for educators to not only receive it, but also to interpret it and translate it into meaningful actions. Three of the monitoring targets identified in Section 2.1 are particularly time-sensitive: struggling students, engagement and presentation of the current topic.

Most forms of direct feedback are geared towards identifying term-wide issues and cannot be conducted or analyzed quickly enough to inform changes for the current topic. Graded performance feedback tends to arrive after a concept has been discussed, and so has limited utility unless the lecturer can find time to discuss it again. In-class sources are naturally timely, while student questions and volunteered feedback can be but are not guaranteed to be sufficient or relevant enough to inform change.

Consensus and motivation

While each student's individual challenges and opinions must be taken into account, not all feedback should result in sweeping changes to teaching practice. The educator has to be able to determine whether feedback given by one or two students only applies to them, or if they are the sentinels of a class-wide problem. Barker and Gruning [3] caught several instances of course lecturers implementing changes that were only requested by as few as one student. Participants tended to overestimate the generalizability of freeform SET comments.

Verify the consensus on student feedback depends on the availability of data from a large portion of the class, which is closely linked to student motivation. The main difficulty in obtaining direct feedback is that students must decide to, or be compelled to, devote additional time and effort to reason and communicate *about* their learning. Since their time and motivation are often limited, this may impact the amount and richness of the data they contribute, and student-initiated forms of feedback may lack

consensus. Also, all direct feedback methods are at their core optional, and students may choose to abstain from giving feedback for a variety of reasons: they may dread the additional effort, they may feel that speaking up is against social or institutional norms, they may doubt that their concerns will be taken seriously, or they may fear reprisal if they identify themselves while being critical of the educator. [3] This often results in direct feedback only emerging in extreme circumstances: when the student has nothing to lose or when the issue has become too frustrating to ignore.

In contrast, students produce massive amounts of potentially useful indirect feedback with no additional effort, simply by virtue of participating in learning activities (e.g., graded performance). Many of these activities have broad participation, so the challenge lies in capturing, accessing, interpreting, and acting on the data they produce.

Richness and context

Interpreting feedback is much easier when the educator can identify precisely under what circumstances the challenge was encountered. Feedback is best obtained in the precise context to which it applies, ideally accompanied by some persistent indication of that context.

Many forms of student feedback are inherently separate from the context in which they originated. SETs are filled out at the end of term with no easy way to reference the concepts taught in the term. Graded performance may capture the context of the evaluation, but certainly not the circumstances under which the relevant information was learned, practiced or understood. In-class tools are correctly situated in the moment, but they tend to yield low levels of detail. Learner-instructor feedback is generally not ideally suited to capturing students' independent or peer-supported learning contexts.

In fact, the combination of timeliness, consensus and richness eludes most feedback methods in this section, as Table 2.2 illustrates:

	Direct feedback					**Indirect feedback**				
Technique	**SET scales**	**SET comments**	**Custom feedback forms**	**Facilitated discussion**	**Volunteered feedback**	**Comprehension checks**	**Graded performance**	**In-class impressions**	**In-class reflection**	**Student questions**
Timely	○	○	○	◐	◐	●	◐	●	●	◐
Generalizable	●	○	●	◐	○	●	●	◐	◐	○
Rich	○	◐	◐	◐	◐	○	◐	○	◐	◐

Table 2.2: Qualities of learner-instructor feedback.

(○: limited support, ◐: occasional or partial support, ●: good support)

In the absence of sufficient sources of timely, rich and course-wide data, lecturers are forced to make teaching decisions based on anecdotal evidence, subjective impressions or single comments from vocal students. [13] Barker and Gruning propose to combat this issue by increasing the frequency of and

student participation in direct feedback initiatives. [3] However, their recommendations are firmly rooted in their participants' experience with learner-instructor feedback and do not consider other sources of data.

2.3 Potential sources of feedback

Lecturers are involved in many aspects of their courses, but a significant amount of student learning takes place outside their purview. Students routinely interact with learning materials on their own or with other learners, and the challenges they encounter are hardly ever captured or reported to lecturers.

It is worth noting that unlike in lecture-based education, analytics of student behaviour such as page views, activity logs, problem attempts and video lecture annotations are widely used for performance and course monitoring in e-learning. Glassman et al. [14], for instance, adapted the muddy cards approach [25] for lecture videos in massive open online courses. Glassman's system, MudSlide, enables students to identify an exact point in a video where confusion originated, making it far easier for lecturers to summarize and act on feedback. This work emphasizes the importance of situating feedback in context.

In this section I propose two potential sources of feedback: peer discussion and document annotation. I situate their use in course monitoring, identify the processes they may offer feedback about that are not covered by learner-instructor feedback, and detail my potential contribution: to explore the suitability of a hybrid peer discussion and annotation system as a source of rich, timely student feedback for lecturers.

2.3.1 Peer discussion

Learner-learner interaction is a powerful element of computer science education. Barker et al. [4] found peer interaction and collaborative learning opportunities to be among the three most important factors in retaining students in computer science. Student often engage in discussions of the course material with their peers, either by choice or as mandated by the lecturer.

When a student indicates confusion with a concept, her peers may respond with a clarification, solving the problem in an example of peer help [15], or they may echo the confusion and collectively seek an answer. If lecturers can access the content of such a discussion, they can use it to determine the extent to which a given issue affects their class. While this is difficult in live communication, learner-learner interaction can be captured and made available to the lecturer in online discussion boards.

A discussion board is a standalone system in which students can initiate or contribute to threaded discussions about the course material. Discussion boards enable persistent, asynchronous and location-disparate communication and have become a valuable tool in post-secondary education. Alongside their applications to learning (which are beyond the scope of this document), they allow lecturers to monitor student questions, gauge consensus and receive potentially anonymous feedback in a persistent setting.

Discussion boards are one of the most commonly consulted course monitoring tools in MOOC scenarios. Stephens-Martinez et al. [35] surveyed 67 MOOC instructors in various fields and asked them to indicate if they would use or were using several sources of feedback, including usage metrics, chat room logs, grades, informal discussions and facilitated surveys. Their findings indicate that instructors valued rich, qualitative data over raw metrics and the discussion board was cited as the source of monitoring data most instructors would use across monitoring goals.

Discussion boards have one major downside: it is difficult to match student questions and feedback to the exact context in which they arose.

2.3.2 Document annotation

Lecture notes, assignment handouts, problem sets and supplementary readings are indispensable elements of a successful teaching strategy. Students routinely grapple with difficult concepts while reading documents and obtaining their reactions to these materials would be extremely valuable in informing timely changes in teaching [36].

Yet, when it comes to the independent study of educational documents, students have very little support in understanding concepts and few mechanisms for bringing their struggles forward. They often work on these documents in isolation, and educators receive no indication of how successful they were until they misinterpret an assignment or fail a test.

Whether reading or re-reading a document, students engage in what Thayer et al. called responsive reading: "developing new knowledge or modifying existing knowledge by engaging with the ideas presented in a text." [37]. Responsive reading is characterized by a set of companion activities that are essential to its success, chief among them annotation: highlighting a passage, adding margin notes or linking two passages together.

Numerous studies [37, 43, 5, 28, 23] cite annotation as a ubiquitous companion activity to responsive reading, and the ability to annotate documents is reported as an essential and often requested feature of digital reading interfaces for education. Annotations vary widely in purpose, content and desired permanence, but they all share a few common properties, namely that their creation is interleaved with the act of reading and that they are **anchored**, i.e, they pertain to a specific portion of the text.

Readers use annotations to process new information, signal importance, record interpretation and inference, work out problems and equations, reflect on the material and highlight confusing areas. [17] This makes annotations reflections of the process of reading: a window into how students think and the confusions they face in the exact moment they occur.

For decades, readers largely annotated on paper since digital interfaces were unable to match its immediacy and ease of use, and so lecturers had no easy way of obtaining student annotations. However, in a recent study of student reading habits, I observed that although participants had fond memories of annotating on paper, they were switching to digital alternatives. Zyto et al. [44] also reported that students are increasingly reading and annotating digitally.

For the first time, student annotations of educational documents may be available as sources of student feedback, but their role in understanding students' interactions with a document is unknown, as is their potential to highlight student concerns, misconceptions and beliefs.

2.3.3 Social annotation

Annotations for personal use are important for the process of learning, but they are nearly inscrutable to anyone but their author and may pose tremendous interpretation challenges. A growing body of work in the emerging area of social annotation (SA) has focused on how annotations may be shared amongst students. SA provides tools that not only let users attach new content to documents, but also allow them to do so collaboratively in real time and to later share their work with project members, classmates, TAs and lecturers. As with individual annotation, content is superimposed on the underlying document without changing it.

In a thorough if slightly dated 2012 review of SA usage in higher education, Novak et al. [27] summarized sixteen studies that deployed and evaluated SA tools such as EDUCOSM [26], HyLighter

[1], Diigo [11], SpreadCrumbs [21] and VPen [20]. The following major findings emerged:

- **Learning gains:** SA-based learning activities contributed to improved critical thinking, reading comprehension, and meta-cognitive skills.
- **Motivation and emotion:** Using SA tools promotes positive emotions and increases motivation to read.
- **Training:** There was an initial performance cost associated with introducing SA technology to students.
- **Attitudes:** Students liked using SA technology and felt that it supported their learning, but SA interactions could at times distract from the underlying instructional activities.
- **Annotation quality:** Strong correlations were found between the quality and quantity of annotations students made and their learning outcomes.

These encouraging results have led to continued interest in SA tools. It is clear that students deepen and enrich their understanding by participating in social annotation. In turn, educators are able to simultaneously access the annotations in context and the interaction between students, which should make SA tools suitable for course monitoring and feedback as well. Shared annotations contain the distilled insight of each reader, curated and formatted for consumption by others [23], and they may give educators a more manageable and interpretable source of data.

The focus of most SA studies has been on the learning outcomes of peer interaction between students, but some SA platforms have gone as far as to encourage broad participation and discussion within each annotation anchor, becoming tools not just for collaborative reading, but for anchored discussion. Once a question, comment, or misconception is made public, other students' responses to it can be hugely beneficial to determining the scope of an issue or the number of students affected, in effect combining the potential benefits of peer discussion and document annotation. Research on anchored discussion boards as platforms for gathering feedback is initially promising, but a much more nuanced exploration of their capabilities, uses, and limitations is needed.

Chapter 3

Anchored discussion boards

Anchored discussion boards combine the capabilities of an online forum with superimposed document annotation, which uniquely positions them to support a wide variety of existing and new feedback activities.

3.1 Background

Digital discussion boards originated as early as the 1960s with the message board feature of the PLATO instructional system [6]. CSILE/Knowledge Forum was developed in the late 1980s [32] by Scardamalia and Bereiter at the Ontario Institute for Studies in Education (OISE) to support knowledge building communities in collaboratively constructing shared knowledge and understanding. Greer et al.'s IHelp peer help system [15] provided discussion board functionality in their Cooperative Peer Response (CPR) tool and matched students to available peer helpers with a Peer Help System (PHelpS), emphasizing the importance of a shared context and digital workspace for their collaborative tasks, while Comtella [40] was used to encourage students to share course-related Web resources and explore their motivations. In 2000, Guzdial and Turns [16] explored the role of discussion forums as tools for collaborative learning, and posited that effective (i.e., conducive to learning) discussion between students should be sustained over many notes, have contributions from many students (writing in discussion boards is "a conservative measure of the extent to which learning can result from the discussion" [16]), and it should focus on class topics.

To support these elements, they introduced CaMILE: a discussion board system that included persistent threading (a feature that is now standard in most discussion board systems) and templates that helped students compose meaningful notes. Most importantly, CaMILE let the lecturer augment external web pages with links to their corresponding discussion threads.

In their evaluation with two consecutive offerings of a second year CS course, Guzdial and Turns found that even this limited form of anchoring a discussion thread to a particular learning document contributed to longer thread lengths, more sustained discussion, and broader student participation.[16] In CaMILE lecturers had to explicitly embed discussion links after documents they deemed interesting, which had a downside: documents and their corresponding discussions were not on the same page.

2002's WebAnn project by Brush et al. [7] went a step further, allowing students to start discussions anchored to any part of the document and superimposing them on the document itself. WebAnn

was a truly anchored discussion board where threads could begin as annotations pertaining to specific portions of the text, theoretically eliminating the need to switch between document and discussion and encouraging more targeted discussions. However, WebAnn was hampered by student reading habits of the time: students were required to add notes in the system, but they were overwhelmingly reading their documents on paper. The comments and replies that ended up on WebAnn were therefore slow to appear there, and much of the benefit of in-context, immediate discussion was lost.

3.2 Nota Bene

The balance between paper and digital reading only began to tip in favour of the latter a few years ago. In 2012, Zyto et al. [44] at the Massachusetts Institute of Technology described an anchored discussion board for social annotation called Nota Bene (NB). Similarly to WebAnn, students could initiate a discussion thread from any rectangular selection in a PDF document.

Zyto et al. [44] reported encouraging adoption data: NB had been used in 49 classes by 32 different faculty across 11 universities. The authors reported the total comments and comments per user for the 15 classes with the most comments that used NB and compared them to classes using Stellar, MIT's unanchored discussion board system. Zyto et al. [44] noted that the five most active NB classes produced more comments than the most active fifty Stellar classes combined. Thirteen of NB's classes had more comments than the most comments captured in any single instance of Stellar.

The most prolific course that used NB was an "Art of Approximation in Science and Engineering" offering at MIT: 91 students produced over 14 000 comments. The lecturer for this deployment, Sanjoy Mahajan, became the evaluation paper's fourth author after his participation in the study was completed.

Mahajan encouraged participation by requiring his students to contribute insightful comments to the weekly readings, demonstrating a *"reasonable effort"* [44]. This task was a modified *"reading memo"* [36] assignment Mahajan had used in previous semesters. After the initial push to participate, students learned to value the system, contributing more comments to later readings and also voluntarily annotating problem sets for which comments were not a course requirement. Analyzing comments from this deployment showed that student seemed to be making comments while reading, and not afterwards. Students were using the spatial location of comments to find relevant threads and their contributions met Guzdial and Turns's [16] criteria for successful collaborative learning.

In an interview after the course, Mahajan mentioned that he used student comments to adjust the content of his upcoming lectures. NB provided an avenue for requests for simpler examples or more explanation: forms of direct feedback that he would not have been able to aggregate from students' previous paper-based submissions. He received this feedback the night before his lecture, gauging consensus from the spatial heatmap of student comments, and could see material that caused the students' confusion in context.

Overall, the authors acknowledge that Mahajan was a very motivated adopter who actively changed teaching strategies to accommodate NB and to encourage student engagement. Their study also focused heavily on adoption metrics and the perceived usefulness of the tool to students, skirting any discussion of learning outcomes. By their own admission, their paper is an existence proof that shows some potential uses of the system in the best case and invites further exploration.

3.3 Potential as a research platform for student feedback

Given the success of NB's deployment and its initial suitability for collecting annotation and peer discussion data that could be used to inform teaching, I propose to use NB as the test platform for my first study of anchored discussion board feedback, detailed in Chapter 4.

In their overview of social annotation literature, Novak et al. [27] outlined a set of desirable features of social annotation tools:

- Work across browsers with no additional software required
- Open, non-commercial architecture
- Maintain the integrity of the original document
- Control annotation visibility (private, shared or public)
- Collate annotations into structured reports
- Allow readers to link and share annotations

NB meets all but the last requirement. It is built using the Django open source Web framework and distributed under the MIT license. It is browser-agnostic and requires no additional software. Notes are attached to the document but distinct from it. Posters have control over the visibility of their comments: only they can see them by default, and they can choose to make them visible to their instructors or to the entire class.

NB is an excellent test environment for a deeper exploration of anchored discussion boards as sources of student feedback. It is stable, open-source, and actively maintained. It can fully replace any non-anchored discussion board while conforming to university guidelines for data retention and privacy. It has all the characteristics of a social annotation system, and it works with the popular PDF file format.

NB was also hinted to be useful in course monitoring and feedback. Mahajan reported using reading memo comments before lecture in order to guide his teaching, and another evaluation of NB with undergraduate biology students by Wright et al. found that NB helped identify student misconceptions and *"offered a sneak peek into the minds of the students"* [42]. However, neither evaluation discussed the details of how NB was used to extract feedback about teaching practice, or how it compared to unanchored discussion boards in this task.

Chapter 4

Initial study

Anchored discussion boards capture the immediacy of student reactions to educational documents [44] while providing a venue for learner-learner and learner-instructor communication and a safe, potentially anonymous space for voicing questions and concerns. I plan to use NB as a platform to investigate how document annotation and peer discussion can be harnessed as feedback sources for computer science lecturers: what kinds of data do they value, what interpretation challenges do they face, and how do they make decisions about their teaching.

4.1 Anchored discussion board feedback

Zyto et al. provided an existence proof for anchored discussion boards: with a motivated lecturer, students wrote lots of comments interleaved with reading and those comments were sometimes used by the lecturer to inform changes in teaching practice. [44] However, there was no indication in that study of *how* comments made in the system translated to actionable changes, what the lecturer's philosophy or approach was to student feedback, whether students were encouraged to give feedback, or what format (direct or indirect) that feedback took. To help answer these questions, I will deploy NB in a case study on student feedback.

4.2 Method

I propose an exploratory multiple case study with three computer science courses:

- One course will use NB as an anchored discussion board that is monitored by the lecturer as a source of feedback
- One course will use an unanchored, but monitored discussion board
- One may use a discussion board but the lecturer will not monitor it

The classes will be selected through heterogeneous (maximum variation) purposive sampling [9]. All will be computer science courses with PDF-based course readings. The unit of analysis for the case study is the lecturers' process of finding, interpreting and acting on student feedback. My main research

question for this study is: *"How does student feedback given in anchored and unanchored discussion boards inform changes in teaching practice in lecture-based classes in CS?"*

Since student adoption of discussion boards is not under investigation, *"reasonable effort"* [44] contributions will be required of students in the anchored discussion board case in order to encourage student participation and to ensure sufficient data for analysis.

A case study is the appropriate method for this investigation since I am attempting to understand a phenomenon in context and I am not deploying any intervention that manipulates the receiving and interpreting of feedback.

4.2.1 Study research questions

- What feedback did lecturers receive?
- What challenges did lecturers encounter in gathering or interpreting feedback?
- What triggered changes in teaching strategies or edits to teaching materials?
- How do discussion board comments inform changes in teaching practice?
- How are anchored and unanchored discussion board different as sources of feedback?

4.2.2 Measures

Data will be collected from a variety of sources to help answer specific research questions and to converge on a rich understanding of how feedback is collected and used in these cases.

Discussion, adoption and context

Zyto et al. [44] collected usage logs from their NB deployment that contained student comments and actions. Discussion board data from our cases will be collected on an ongoing basis throughout the case study and similarly analyzed for three main purposes: effective discussion, topic analysis and prompts for explorations of teaching change.

Cases will be assessed against Guzdial and Turns' [16] criteria for effective collaborative learning discussion (broad, sustained, on-topic). Comments will be coded by topic [16] and the percentage of on-topic comments will be analyzed. This will also help identify comments that constitute direct feedback about each course. Participation and adoption metrics such as comments per user will be extracted from the logs as a sanity check to help situate each course with respect to Mahajan's NB deployment [44]. Finally, comments and discussion threads will also serve as prompts for understanding the context in which lecturers used them to make changes to their teaching.

Community

Students' sense of community will be measured in each of the three cases using Rovai's Classroom Community Scale. [31] As the classes chosen will be full term (12 week) classes, the scale can be administered at the beginning and at the end of the term.

Changes in teaching as a result of feedback

In Zyto et al. [44], one 5-page reading assignment's comments were analyzed for content. 26% of student notes were classified as direct feedback for the instructor. This was encouraged by Mahajan who insisted that rather than being a means of evaluating students, *"student annotations were assessments of how well he was doing as an explainer"*. [44] He made student comments due the night before lecture and reported that he was able to adapt his upcoming lectures based on student requests and confusion. This is mentioned in the paper, but the precise details of the process or the lecturer's strategies for interpreting feedback were not explored.

Event-triggered experience sampling will be used to capture instances of lecturers receiving feedback: in all three cases, they will be asked to fill out a form when they are made aware of feedback, regardless of its origin or medium. The criteria will encompass direct or indirect feedback, and lecturers will be able to specify how they interpret the feedback given and whether any changes were made.

Interviews will be conducted with lecturers at the end of the term to understand how these instances of feedback resulted in changes to teaching practice. Student comments from discussion boards may serve as prompts if the feedback was received there. Interviews will also investigate lecturer attitudes towards feedback, and how they treat student feedback in their classes.

Appendix A

Research direction and tentative timeline

The goal of my Ph.D. is to improve access to feedback data for lecturers by making available and evaluating new or underutilized sources of feedback, more specifically the anchored discussion of teaching materials. My overarching research questions are:

- How can anchored discussion boards be used to inform changes in teaching practice?
- What are the effects of anchoring on lecturers' ability to interpret student feedback obtained from discussion boards?
- What are the limitations of anchored discussion boards as sources of feedback?
- How can interpreting student feedback from anchored discussion boards be made easier and less time-consuming for lecturers?

My first study will focus on understanding the lecturer's perspective on anchored discussion and feedback in a real-world context. To investigate the student's side of the feedback process (what avenues students use, how they perceive their role, what compels them to give or withhold feedback), I will conduct a survey questionnaire, recruiting broadly from undergraduate students in a computer science department. The combined results of these studies will establish the potential uses of anchored discussion in course monitoring and highlight areas where the current crop of SA tools can be improved. I will then build upon the functionality of NB or create a new anchored discussion board system that takes into account the challenges I have uncovered in giving, receiving, interpreting and acting on feedback and tries to alleviate them. An evaluation of my system will follow, ideally in similar contexts (same course, same lecturer) as the original NB deployment.

Below is a tentative timeline (to be discussed in research proposal meeting):

Semester	***Activities***
Summer 2016	Case study of CS courses Student survey questionnaire Write literature review chapter
Fall 2016	*Internship* (Analyze data)
Spring 2017	Analyze data **Submit thesis proposal**
Summer 2017	Build or adapt ADB system to support feedback
Fall 2017	Evaluate system
Spring 2018	Analyze data Write thesis
Summer 2018	Write thesis
Fall 2018	Write thesis **Defend thesis**

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