# CourseMIRROR: Enhancing Large Classroom Instructor-Student Interactions via Mobile Interfaces and Natural Language Processing

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## Abstract
Interactions between students and instructors are crucial to the success of learning and teaching. However, such interactions are limited in large classrooms (e.g. STEM courses and MOOCs). We present CourseMIRROR (**M**obile **I**n-situ **R**eflections and **R**eview with **O**ptimized **R**ubrics), a mobile system that prompts students' self-reflection and in-situ feedback to enhance the interactions. CourseMIRROR uses automatic text summarization techniques to aggregate students' feedback and present the most significant ones to both the instructors and the students to help them understand both difficulties and misunderstandings encountered. In two semester-long pilot deployments involving 20 participants, we received positive feedback from both students and instructors. We highlight major findings as well as the lessons learned.

## Author Keywords
Education; mobile interfaces; reflection prompts; natural language processing

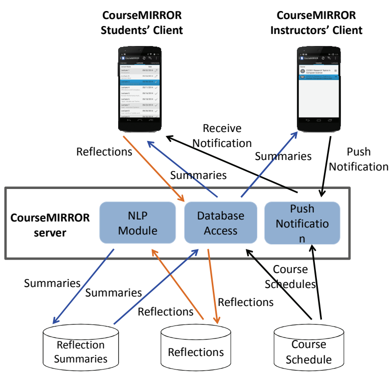


**Figure 1**. Workflow of CourseMIRROR.

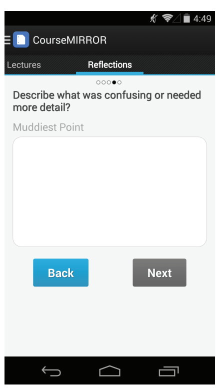


**Figure 2**. One of the reflection writing interfaces (student side).

## ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## Introduction

The degree and quality of interactions between students and instructors are critical factors for students' engagement, retention, and learning outcomes across domains [9]. Although many suggestions and innovations have been proposed, interactive engagement is still very limited between students and instructors, especially for large classrooms (e.g., undergraduate level introductory STEM courses) and online courses (i.e., MOOCs). It's safe to predict that the class size problem will only get worse in both traditional classrooms and online courses. Therefore, enabling *timely* and *sustained* reflections and feedback becomes crucial for quality education.

In recent years, researchers in education have demonstrated the effectiveness of using *reflection prompts* [2] to improve both instructors' teaching quality and learners' learning outcome in areas such as teacher education and science education [2][8]. However, administrating, reminding, collecting student responses, as well as summarizing the gist of student reflections for instructors in a timely manner, is challenging and expensive in large classrooms. As a result, most existing research efforts on *reflection prompts* focus on post-hoc analysis, learners' self-reflections, and learner-to-instructor feedback. Little efforts has been made to facilitate instructor-to-student, student-to-student interactions in a timely manner in large classrooms.

To address these challenges, we propose CourseMIRROR (Figure 1, dubbed Mobile In-situ Reflections and Review with Optimized Rubrics), a mobile system integrated with Natural Language Processing (NLP) techniques for collecting and sharing learners' reflections and feedback in large classrooms. CourseMIRROR actively prompts students to reflect on the lectures and collects their *in-situ* feedback immediately after each lecture. CourseMIRROR also uses text summarization techniques to aggregate the reflections and present the most significant ones to both the instructors and the students so as to identify the difficulties and misunderstandings encountered in lectures. CourseMIRROR[1] is freely available for classroom usage.

We first describe the design of CourseMIRROR. Then we report preliminarily findings from two semester-long pilot deployments (i.e., CS2610 and CS2001 at the University of Pittsburgh in fall 2014) involving a total 20 participants. We also highlight lessons learned and future plans of CourseMIRROR.

## Related Work

Computerized reflection and feedback collection is relevant to the Experience Sampling Method (ESM) [6] and Diary Studies [3] in HCI. Although systems such as Momento [3] and MyExperience [5] support event-contingent ESM via either SMS or context activated polling, they were not designed and optimized in an

[1] CourseMIRROR homepage: http://www.coursemirror.com Free download link in Google Play Store: https://play.google.com/store/apps/details?id=edu.pitt.cs.mips.coursemirror

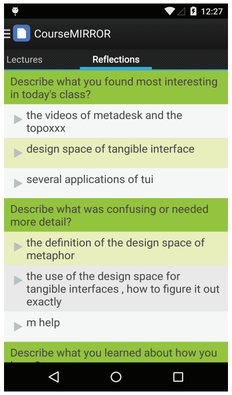


**Figure 3**. Summary display interface of CourseMIRROR (student side).

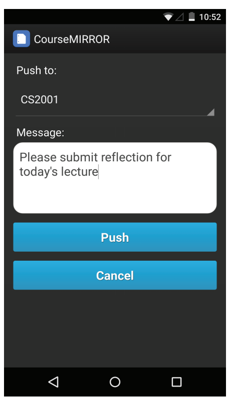


**Figure 4**. Push notification interface of CourseMIRROR (instructor side).

educational setting. In comparison, CourseMIRROR collects in-situ reflections via optimized reflection rubrics inspired by recent progress in educational research [2][8]. CourseMIRROR also goes beyond existing research on *reflection prompts* by leveraging automatic text summarization techniques to student-to-instructor feedback and peer-learning in large classrooms.

## Design of CourseMIRROR

A recent survey [4] indicates 83% of undergraduate students in the U.S. own a mobile phone and the ownership levels will increase steadily. The instant on, always connected ability of mobile devices could allow students to provide *in-situ* reflections efficiently. In addition, the unique modalities of the mobile devices (e.g. camera, microphone) could also provide richer channels for students to generate reflections in future versions of CourseMIRROR.

Figure 1 shows the workflow of CourseMIRROR. The students could access the courses enrolled as well as the corresponding lectures via two list views. After each lecture, students write and submit reflections through CourseMIRROR (CourseMIRROR allows instructors to load customized reflection questions). These reflections are transmitted to the server and stored in the database. Figure 2 shows a sample reflection prompt on CourseMIRROR' mobile app. In order to collect in-situ feedback, CourseMIRROR imposes submission time windows synchronized with lecture-schedule (i.e. students can only submit reflections on one lecture from the beginning of the lecture to the beginning of the next lecture). Instructors can also send customized reminders for reflections or generic feedback via mobile pushing notifications to the students' devices.

After the reflection collection phase, CourseMIRROR runs automatic text summarization algorithms on the server to generate a summary of reflections for each lecture. This summary intents to emphasize both the *representative* (what is the typical reflections and feedback), and expose the *diversity* of the students (who delivered the reflections/feedback) so as to mimic a corpus of summaries created by a TA from hand-written reflections [8]. We explored *word level*, *phrase level* and *sentence level* summarization methods and chose *phrase level* techniques based on pilot tests. We found phrases are easy to read and browse just like keywords, and fit better on small devices when compared with sentences. The phrase level summarization is ideal in that it provides *more coverage* under a given text length limit. We designed a text summarization algorithm for CourseMIRROR on top of the MEAD platform [7]. Our algorithm is optimized for generating phrases rather than sentences and consists of three key steps: First, using a syntax parser to generate candidate phrases (i.e. noun phrases); Second, grouping the candidate phrases via the K-Medoids clustering algorithm; Third, reranking phrases by student coverage. Experimental results show that our algorithm generates better results than existing techniques such as LexRank.

Figure 3 shows the reflections summary interface of CourseMIRROR. For instructors, we hypothesis that relevant and coherent summaries can help them quickly identify students' misunderstandings and cater future lessons to the needs of students. For students, reading these summaries can remind them to recapture the learning contents and reflect on them. To motivate the students to read the summaries, CourseMIRROR highlights the phrases (by using light-yellow

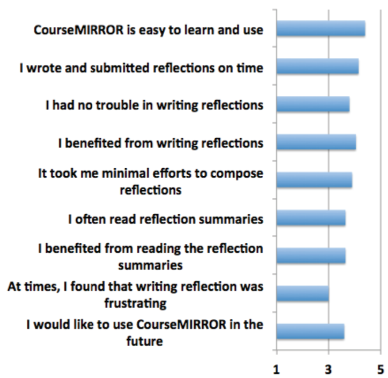


**Figure 5**. Modes of ratings on a 5-Likert scale.

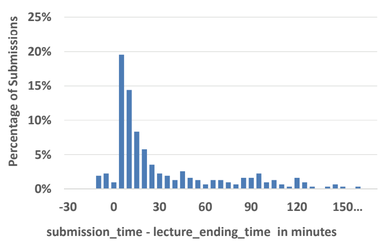


**Figure 6**. Response time distribution histogram.

background, Figure 3) that were included or mentioned by the current user. We hypothesize that highlighting the presence of one's own reflections in the summaries can trigger the students' curiosity; thus they would be more likely to spend some time in reading the summaries.

## Implementation

CourseMIRROR includes two components, the client side and the server side. We have created a native mobile app for the Android platform and a mobile HTML5 optimized web client for iOS, Windows Phone, Black Berry, and PCs (the native iOS app is under development). We used the Parse [1] platform to build the CourseMIRROR server.

## Pilot Deployment

In order to investigate the usability and efficacy of CourseMIRROR, we conducted semester-long deployments in two graduate-level courses (i.e., CS2001 and CS2610) at the University of Pittsburgh in fall 2014. CS2001 is an introductory course on research methods in Computer Science. CS2610 is a graduate level course on introductions to Human Computer Interaction. 20 participants (6 out of 13 in CS2001, 14 out of 22 in CS2610; 5 female) enrolled in the deployments and were financially remunerated. All participants were graduate students in Computer Science (13 Ph.D. students, 7 master students). Each of these two courses had 21 lectures that were open for reflections; and we collected a total of 344 reflections from the pilot deployments. Each reflection contains the answers to three questions:

- *"Describe what you found most interesting in today's class"*
- *"Describe what was confusing or needed more detail"*
- *"Describe what you learned about how you learn"*

We intentionally chose to use the same reflection questions as the study by Menekse [8] (handwritten reflections and summaries created by a TA), so as to investigate the impact of mobile devices and NLP on experimental results. We also collected closing questionnaires in the last lecture of each course. Overall, participants reported positive experiences with CourseMIRROR according to the closing questionnaire (Figure 5).

***Finding 1**:* Students were willing to submit reflections in a timely manner.

Throughout the fall semester, participants submitted an average of 17.1 out of 21 reflections, i.e. 81.4% (min = 8, max=21, $\sigma$ =4.2). This response rate is encouraging considering that there was a significant portion of quiet and shy students who rarely asked questions or seek for help actively in each lecture. We further analyzed the time when the students submitted the reflections and found 59.0% of the reflections were submitted within half an hour after the end of each lecture. We even observed that 5.1% of the reflections were submitted before the end of the lectures. Figure 6 shows the response time distribution histogram. These results confirmed that the reflections were *in-situ* as we expected. We attribute the high response rate in part to the novelty and efficacy of our CourseMIRROR mobile client. A potential confounder might be the *selection bias* in the voluntary enrollment process. Anyway, allowing more than 50% of students in a course to generate at least 8 reflections per semester

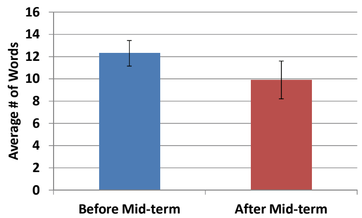


**Figure 7**. Average number of words in each reflection before and after mid-term.

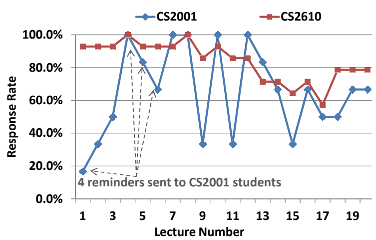


**Figure 8**. Response rates (i.e., submission ratio) of the two courses.

at minimal administrative efforts is still impressive. We have scheduled larger scale (200+ participants), randomized experiments in the near future to further verify this finding.

***Finding 2****: Students wrote fewer number of words per reflection over time.*

The students wrote fewer words in the reflection over time (Figure 7). The average number of words per reflection was significantly higher than that after mid-term (12.3 vs. 9.9, $p<0.001$). At the same time, we observed that some meaningless answers (e.g., "None", "No", "N/A") emerged over time.

We identified two explanations through the post-deployment interviews and the closing questionnaires. First, students were busier during the second half of the semester. One student complained that he had "*four large course projects*" and "*don't want to spend time thinking about the reflections*". Another student suggested that CourseMIRROR could have some "*multi-choice questions*" so that "*it can save time, especially during the final weeks*". Second and more importantly, the repetitive nature of *reflection prompts* can make students bored. Three students mentioned that "*don't want to answer the same questions every time*" in the closing questionnaires.

To address these two problems, we plan to explore the usage of multiple reflection prompt protocols (e.g., voluntary collection, random sampling, and scheduled collection) to save the students' time. We will also explore some enhanced reflection collection techniques (e.g., NLP enhanced active reflection collection, speech based reflections, camera based reflections) and visualization techniques to make the reflection collection process more interesting and time efficient.

CourseMIRROR will encourage the instructors to load lecture-specific reflection prompts to improve the diversity and coverage of *responses*.

***Finding 3****: Active reminders via emails and push notifications can increase the response rate.*

CourseMIRROR sent automatic, lecture time-triggered reminders to students in CS2610 via an email-list and push notifications after each lecture; CourseMIRROR only sent four reminders to CS2001 students (students in CS2001 submit reflections without active reminders in most lectures). T-test shows that the response rates of CS2610 is significantly higher than that of CS2001 (86.4% for CS2610 vs. 65.8% for CS2001, $p<0.001$, Figure 8).

***Finding 4****: Composing reflections in CourseMIRROR benefits students by encouraging them to revisit key concepts in class.*

Participants felt that they benefitted from writing reflections. Sample comments include:

- "*It is helpful as while writing you are in a way doing a mental recap of the entire lecture.*"
- "*Doing summary about the new materials help you organize it in your mind.*"
- "*It takes a short time but can review the knowledge.*"

"*It helps me to refresh the memory and figure out what I didn't understand.*"

***Finding 5****: Students enjoyed reading summaries of reflections from classmates.*

The students responded positively on the ability to see summarized reflections from their classmates:

- "*That reminds me, oh, I'm also confused about that point, but I didn't notice that before*."
- "*It's interesting to see what other people say and that can teach me something that I didn't pay attention to.*"

The participants also like the idea of highlighting their own viewpoints in the summaries (Figure 3):

- "*I feel excited when I see my words appear in the summary*."
- "*Just curious about whether my points are accepted or not*."

## Conclusions and Future Work

We present CourseMIRROR (Mobile In-situ Reflections and Review with Optimized Rubrics), a mobile system that leverages mobile interfaces and NLP to enhance *reflection prompts* in large classrooms. CourseMIRROR uses mobile interfaces and active reminders to collect learners' reflections and feedback in-situ. CourseMIRROR also uses automatic text summarization techniques to aggregate students' feedback and present the most significant ones to both the instructors and the students.

Our pilot deployments showed that CourseMIRROR is promising to enhance the interaction between students and instructors.

The pilot studies also revealed challenges for future research: 1) how to maintain students' sustained-motivation via diversified *reflection prompts*? 2) How to design multi-modal reflection prompt collection mechanism that encourages informative responses within a relatively short time? 3) Whether and to what extent CourseMIRROR can improve the students' *learning gain*?

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