Exploring LLMs in a Reflective Teaching Toolkit for Engineering Faculty

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Abstract
Teaching evaluations are important for faculty development and promotion. However, poorly designed teaching evaluations are often inherently subjective. Therefore, an increasing number of institutions are seeking ways to create holistic evaluation processes for engineering instruction and teaching. At the University of Illinois Urbana-Champaign, the institution is piloting a new system for defining and evaluating excellent teaching based on four major criteria: instruction design, instruction delivery, inclusivity and ethics, and reflection and evolution. In this paper, we outline a teaching toolkit designed for engineering faculty to support the university's goal of documenting reflective teaching practices. Our initial motivation is to mitigate the perception of reflection practices as time-consuming and abstract. The toolkit presented here is designed as a guide for faculty to reflect on teaching practices, set goals for teaching improvement, and conduct student surveys and focus groups to support the goals. This toolkit is piloted in three Aerospace and Bioengineering courses. The lessons learnt from the toolkit development support faculty in documenting reflective teaching practices and lower the barrier for entry for engineering faculty to engage in reflective processes with peers and students.

The toolkit can be found at https://publish.illinois.edu/reflectiveteachingtoolkit/.

Introduction
Reflection is an important faculty development tool that remains underutilized in engineering education [1,2]. Reflection on one's teaching provides a basis for making pedagogical decisions and leads to improvements in teaching practices [3]. Prior work has shown that it prompts faculty to think more deeply about their teaching [4] and become more intentional in choosing learning activities [5]. Reflection causes faculty to change their approaches to adopt more student-centered teaching practices [6]. Reflective strategies for faculty can include journaling, peer observations, and focus groups or course assessment data from students [7]. Despite these documented benefits, reflective practice is often abandoned or minimized in engineering contexts. Competing demands on instructors' time, along with perceptions that reflection is at odds with notions of technical rigor, contribute to its neglect [7]. Difficulties in implementation are compounded by a lack of guidance for engineering faculty on best practices for reflection. Machost et al. [8] found that over 80% of physics and astronomy professors in their study wrote low-level (i.e., not considering their beliefs, values, and educational literature) reflections that are insufficient at promoting instructional change. Minimal levels of engagement in reflection [6] or informal reflections between colleagues [7] are also ineffective approaches to reflection that tend not to result in positive instructional changes.

These findings suggest that encouraging reflection alone is not enough. Engineering faculty need guidance, structure, and tactical tools to assist with effective and efficient reflection. Hence, we are creating a reflective teaching toolkit to help faculty developers and instructors move beyond surface-level reactions to student feedback and towards intentional, values-informed instructional decisions. Our toolkit integrates multiple sources of information and scaffolds each component with appropriate tools that help to collect and interpret data, translating reflection into concrete instructional changes. It begins with pre-semester instructor self-assessments that identify key areas of growth. It is followed by early informal student feedback that is formulated to corroborate the self-assessment results. Qualitative data analysis from student feedback is employed to gain further insights through focus groups using Language Learning Models (LLMs). These LLMs are Artificial Intelligence systems designed to process and generate human-like text by learning patterns from extensive training data. LLMs have also proven effective in finding relevant data and facilitating the efficient analysis of large datasets [9]. Rather than positioning student feedback as summative, the toolkit frames it as formative to support growth in ways that are sustainable, meaningful, and actionable.

This paper describes lessons learned from the development and testing of the reflective teaching toolkit among three engineering faculty members and two student researchers who engaged in developing a reflective teaching toolkit from an instructional faculty perspective. Together, our differing roles provided complementary viewpoints on the design, facilitation, and analysis of student feedback-informed reflection. Figure 1 shows the reflective teaching toolkit steps and the five lessons learned associated with different stages of the reflection process. Toolkit users can enter the reflection process at any stage and skip steps as needed. However, progression through all steps will produce a stronger reflective practice. The toolkit can be found at https://publish.illinois.edu/reflectiveteachingtoolkit/.

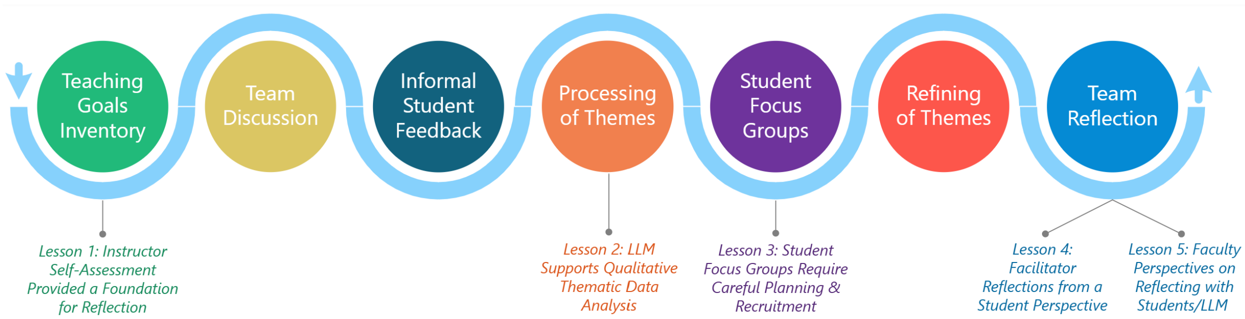

Figure 1. The toolkit workflow was tested in this project and associated lessons learned at specific points in the reflection process.

Lessons Learned

Lesson 1: Instructor Self-Assessment Provided a Foundation for Reflection

Background and Methods: A core goal of the reflective teaching toolkit is to support instructors in developing greater self-awareness about their teaching values, priorities, and practices. To this end, one of the faculty team members identified useful evidence-based teaching assessments that could serve as structured entry points for reflection: a Teaching Goals Inventory [10] and a Teaching Practices Inventory [11]. Instructors were invited to complete one or both inventories and then engage in guided reflection on their results. These reflections occurred individually and/or through small- or large-group discussions with colleagues. Inventories were used not as evaluative measures, but as prompts to surface assumptions about teaching and learning.

Lesson Learned: Completing these inventories helped participants to recognize the wide range of possible teaching goals and practices that can exist within different formats of engineering courses. The results clarified the instructors' instructional priorities while also revealing goal categories not previously considered. The inventories provided shared vocabulary that made it easier to communicate teaching intentions to students and colleagues. The instructor found that this clarity supported more intentional decisions about instructional materials, homework assignments, and assessments. The motivation to complete the assessment was initiated by an invitation to join a community of practice that fostered a space to ask questions, share thoughts, and challenge ideas. While forming a community of practice around reflection reduces the barrier to entry and may make it easier for faculty to make time for this activity through group accountability, it is not a strict requirement. We recommend using the structured self-assessments as a starting point of the reflection process that grounds subsequent interpretation of student feedback in the instructor's stated values, rather than in isolated comments or numerical scores.

Lesson 2: LLM Supports Qualitative Thematic Data Analysis
<u>Background and Methods:</u> Given that reflection can be an uncomfortable activity for some engineering faculty, communities of practice can help. In the absence of opportunities to reflect with others, LLMs (e.g., GPT and Gemini) can reduce the barrier to reflection. Thematic analysis of qualitative data [12] can be time-intensive, requiring codebook development and multiple coders to achieve inter-rater reliability [13]. Thus, analyzing qualitative student feedback may present a barrier for instructors without training in qualitative methods. We compared thematic analysis conducted by an experienced human coder with analysis generated using LLMs. LLM was prompted to identify themes and associate them with representative quotes.

<u>Lesson Learned:</u> LLM proved effective at quickly identifying common phrases and sentiments across large data sets. Although it was a useful starting point for analysis, the generated themes often benefited from refinement and contextualization through a human review that captured more nuanced interpretations and a more holistic understanding of the data. For example, one of the themes identified in the Informal Early Feedback (IEF) survey responses from 53 students on course writing assignments was "clarity in writing expectation." The number of student responses associated with this theme by the LLM tool was 9, but human coding found at least 23 responses that fit the theme. Table 1 shows a sample comparison of the thematic responses between LLM and the human coder. We therefore recommend using LLM as an initial analysis tool that can make qualitative reflection more accessible, followed by human sense-making to deepen interpretation. We believe that this approach makes qualitative data analysis more accessible and could present educators with clear, organized data for reflection.

Table 1. Student responses coded as the theme "clarity in writing expectation" by LLM and a human coder.

<table>
<tr><th>LLM (all 9 responses)</th><th>Human Coder (taken from a sample set of 13)</th></tr>
<tr><td>• Knowing what to write to analyze data
• Deciding what content goes where.
• Answering in each section: what did we do, how did we do it, why did we do it, etc.</td><td>• Showing more examples of good writing style and correct formatting.
• Providing more information on how an assignment should be written.
• Giving enough examples of each section (theory, experimental, etc.).
• Speaking in/including an appropriate amount of detail.
• Knowing what to do with conflicting information.
• Explaining unclear rubrics in more depth.
• Using language that is as specific and accurate as expected.</td></tr>
<tr><th colspan="2">Both LLM and Human Coder</th></tr>
<tr><td colspan="2">• Fully understanding what is needed for the theory section.
• Knowing what is sufficient information for each section, i.e., what is adequate or too much when writing.
• Knowing what to include and focus on, particularly for each section of the report
• Understanding what the expectations are, especially given space constraints.</td></tr>
</table>

Lesson 3: Student Focus Groups Require Careful Planning and Recruitment
Background and Methods: Student focus groups were incorporated into the toolkit as a follow-up to IEF surveys. The intent was to use open discussion to clarify survey themes and explore nuances that students might not articulate in written responses. Recruitment strategies included in-class announcements and compensation incentives. Facilitation guides and discussion prompts were developed based on IEF results. Despite this preparation, participation was lower than anticipated, and some students who initially expressed interest did not attend the sessions.

Lesson Learned: Recruiting students for voluntary focus groups required more intentional effort than expected. Incentives alone were not sufficient. We recommend that the focus group recruiters allocate ample time for outreach and start the process early with multiple rounds of reminders. Integrating reflective discussions into class time or offering course credit will also be helpful for better engagement. Moreover, flexibility in facilitation proved essential. Smaller-than-expected groups changed the dynamics of the discussion and required adaptation of the facilitation plan. Logistics and recruitment are not peripheral concerns; they are central to the success of focus groups as reflective tools.

Lesson 4: Facilitator Reflections from a Student Perspective
Background and Methods: Student facilitators played a critical role in designing and conducting focus groups, bringing additional perspectives to the reflective process. First, undergraduate and graduate student researchers collaborated with faculty to design and facilitate focus groups after the collection of IEF survey data. Results were then used to identify preliminary themes and inform the development of guiding questions for the focus groups. A graduate student researcher worked with a co-facilitator to develop the question protocol and run the sessions. LLM tools were used to support efficient brainstorming of focus group questions, and IEF results provided a baseline for developing clarifying and probing prompts. Draft protocols were shared with the instructor for feedback to ensure alignment with the instructor's reflection goals.

Lesson Learned: From the perspective of the undergraduate student facilitator, focus groups revealed how dialogue among students can generate more detailed and nuanced feedback than surveys alone. Hearing students build on one another's comments highlighted themes and actionable areas for course improvement, while also underscoring the need for intentional facilitation to ensure equitable participation in larger groups. From the perspective of the graduate student facilitator, combining IEF-guided questions with more general prompts supported richer discussion and surfaced student experiences that might not have appeared in written feedback. As a student themself, they found it easier to relate to and interpret student concerns, contributing to a comfortable environment in which participants openly discussed ideas and responded to one another. At the same time, they noted that this dynamic may be more difficult to replicate in groups where participants are less familiar with one another. Together, these perspectives suggest that involving students as facilitators strengthens the reflective teaching toolkit by improving question design, fostering open dialogue, and helping instructors translate student feedback into instructional improvement.

Lesson 5: Faculty Perspectives on Reflecting with Students/LLM
Instructor 1: On Reflecting with Students/LLM: These practices were tested in an established design course [14]. To this point, this instructor has handled classroom reflection on their own.

Before this project, this instructor administered IEF irregularly and received semesterly, post-course university-administered feedback. Testing the reflective teaching toolkit was this instructor's first opportunity to work with a team on reflection [15,16]. Given the time constraints of the semester, using an LLM to summarize the IEF helped to manage time and objectively review the feedback. Rather than taking individual comments personally, the use of an LLM allowed this instructor to generate themes and action items simultaneously, creating a forward-thinking reflection rather than dwelling on mistakes. The speed with which multiple formats of the data can be generated with LLMs was helpful as well. Being able to view the same information in a table, in a paragraph, and in bullet point format would be time-intensive if done by hand. Using LLMs to summarize student feedback makes reflection easier to fit into a typical teaching workflow and translate into course improvement.

<u>Instructor 2: On Using the Toolkit in a Focus Group for a New Class:</u> These practices were tested in the first iteration of a Neural Engineering laboratory course with 8 students of varying experience. Researchers on the team prepared questions from which this instructor selected a subset pertaining to lab courses in general and this new course specifically. All students participated in an hour-long focus group [14] conducted during class at the end of the semester. Having a small class size was ideal for including the entire class, but facilitators reported that some quieter students were still left out. This instructor then met with facilitators to debrief the main LLM-organized themes and brainstorm changes for the next semester. The timing allowed for larger themes as well as specific comments; however, a mid-semester evaluation would have produced more immediately actionable steps. Based on the use of both IEF and focus groups, we recommend IEF for short-term, intra-semester changes and use focus groups for major, inter-semester improvements.

Conclusion

This paper describes a reflective teaching toolkit designed to help engineering instructors engage more deeply and productively with student feedback. Rather than treating feedback as an evaluative endpoint, the toolkit frames it as formative data that can support intentional reflection and instructional decision-making when paired with appropriate structure and support. Several key insights emerged from the lessons presented: (1) Structured instructor self-assessment provides a foundation for reflection by clarifying teaching values, priorities, and language, allowing student feedback to be interpreted in context rather than in isolation. (2) LLM-based qualitative analysis tools can lower barriers to engaging with open-ended feedback by providing efficient initial sense-making, while human interpretation remains essential for depth, context, and meaning. (3) Student focus groups can generate richer and more nuanced insights than surveys alone, but their effectiveness depends heavily on thoughtful recruitment, logistics, and flexible facilitation. (4) Involving students as facilitators and partners in the reflective process offers valuable perspectives and helps bridge the gap between student experiences and instructional design. (5) For faculty aiming to bring reflection into their classrooms, LLMs are a useful tool to summarize responses and generate action items for improvement. With the many pulls on faculty time, LLMs reduce the burden of bringing reflection into the classroom. Together, these suggest that effective reflective practice in engineering education is not a single activity but a scaffolded process that integrates multiple tools, perspectives, and roles. Our future goal is to incorporate these lessons in the design of the toolkit that supports instructors to move from feedback to reflection and sustainable instructional improvement.

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