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Increasing In-Class Participation in Materials Science Education through Anonymized Discussions

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Activities with Impact!

Increasing In-Class Participation in Materials Science Education through Anonymized Discussions

Allowing for anonymous input in class discussions has been found to increase student participation, which is important because it is known that student participation during class time is correlated to academic performance. This is likely because student hesitation in participating is related to concerns of embarrassment, language barriers, and social anxiety that are alleviated by anonymous discussion methods. In this work, TopHat discussions in "anonymous" mode are used to create an inclusive environment for discussions in materials science courses, allowing students to contribute without the fear of being judged. This approach has been implemented in both a large introductory course (200-350 students, including materials majors and non-majors) and smaller, focused courses (20-60 materials majors) from sophomore to senior levels. The use of anonymous discussions significantly increased participation in all of these contexts. Anonymous questions can be applied to quickly determine if the students understand a concept prior to its introduction in class, to have students share their answers to example problems, or to have multipart back-and-forth conversations with the class at large. For example, a conversation could start with a big picture question such as "why are [X material] good for [Y application]" or "why might [X conditions] lead to failure in [Y material]"; the professor can read aloud some of the initial answers, provide input on these, and continue seeking further comments. This can include creating and adjusting questions in real time during class. Examples of these activities with their associated participation rates in anonymous discussions will be presented.

Background

Prior work has shown that active engagement in class, beyond simply attending class, leads to increased academic performance [1]. However, some students face social anxiety or fear being embarrassed if they were to make a mistake, which is prevalent especially in front of peers [2], [3]. This has been connected to student reluctance to participate in class discussions [4].

One way to coordinate active engagement on discussion topics with reduced concerns of anxiety or embarrassment is to allow students to participate anonymously [5]. Indeed, student surveys in prior work showed that a majority favored anonymity when they were not sure about their answers [6]. Other works indicated that, by making student submissions anonymous in online asynchronous discussion boards, one can increase student engagement in the discussions [7], [8]. Also, replacing face-to-face collaborative group work with an anonymous online chat room has been found to increase student performance [9].

Switching to student-identified discussions to anonymous discussions to potentially increase engagement involves several considerations and likely will require adjustments to the details of how the discussion is hosted and moderated. Here, I discuss specific methods and lessons learned from including anonymity in a live class discussion, which is in place of a typical class discussion. I use active learning/polling software to host these class discussions by asking a

question (often open ended) and then displaying a running feed of electronically submitted student responses on the screen. This allows me to have a conversation with the class at large: responding to specific student comments and questions while not calling out any specific student.

Importantly, in all cases of introducing anonymity, I have employed student-to-student anonymity while keeping the ability for the host to identify the submitters' names. This is because a common challenge for faculty in utilizing anonymous participation is the potential for inappropriate posts by students due to their anonymity [8], [10]. Keeping the ability for the discussion host to identify students mitigates this risk and potentially also allows one to also assign participation points, though in my courses these discussions are not a graded activity. It has been my experience that the posts stay on topic and appropriate when using these techniques for both large (200-350 student) and smaller (20-60 students) courses. Note that the students are told only that their comments are anonymous to other students during class; I have not discussed with students whether or not they can be identified later, nor have I had an instance where an inappropriate comment required me to identify a student.

Anonymous Live Discussions with TopHat

There are multiple software options to host live discussions with multiple synchronous submitters. Typically, the instructor posts a discussion topic or question, and students use a personal phone, tablet, or laptop to type in responses (or, optionally, provide digital sketches), and this can be done through a web browser on both sides without needing to download an application. Here, I use TopHat, which has multiple functionalities for use as an active learning platform [11] and is able to run anonymous discussions. This is a paid service to which Ohio State University has a subscription. Relevant alternatives include the paid software Poll Everywhere [12] and free option Kialo Edu [13]. One can also repurpose existing more familiar tools such as anonymous discussion boards on a learning management system (Canvas and Blackboard both have this capability) by setting the discussion to be only open briefly during class, and reviewing the results with the class as they come in.

Using TopHat or similar software, an instructor is able to assign a discussion and project a live feed with anonymized student responses (which can include text and, optionally, digital sketches), while student submissions are still saved elsewhere in the system with their names attached. The saved data could be used, for instance, to later address any inappropriate responses with the submitters [11]. I retain the ability to see the student responses through TopHat, however, in facilitating these anonymous discussions in 8 classes over the past two years, I have not needed to identify the students. I have only had mildly inappropriate responses (usually off-topic jokes), which I either ignored (to avoid encouraging the student) or replied to with a simple "don't do that" and moved on.

Types of Questions and Discussions

I use relatively open-ended questions to promote discussion and learning in the anonymous TopHat response format, similar to questions used to start a typical brief in-class discussion. Sometimes, the question is targeted at a specific concept and has correct and incorrect

potential answers but is still open ended enough that it encourages the students to share the reasoning behind the answers and think more clearly about the physical situation. In other cases, the question can be very open-ended to simply promote engagement and check on the prior knowledge or interests of the class. I have also successfully asked for graphic/sketch based responses. In the following, I give examples of specific discussion questions of these three types that I have used in certain materials science courses, and how the ensuing discussion has proceeded.

Example 1: back-and-forth discussion between instructor and class

In spring semester 2025, in a sophomore-level materials science class (50 students) on numerical and statistical methods, after discussing cross-validation in a machine learning algorithm (LASSO), I used the discussion topic "In the example, we fit our final parameters to the full dataset, so what was the point of the cross validation?"

The responses were projected to the class as they came in.

I read a few of the responses to the class and provided simple feedback such as:

- Student comment example: "find the best lambda [the regularization parameter]". Instructor, said aloud: "Yeah, to find the best lambda"
- Added prompt, out loud: "How does it find the best lambda?"
- Student comment example: "To find the smallest value of validation error". Instructor: "So it's the one that's most predictive of data that you didn't fit. Because if you set lambda too low, you're overfitting. If you set lambda too high, you're underfitting."
- Added prompt: "If I ran this 2 times, would I get the same result? Why or why not?"
- Student comment example: "No it's randomly split". Instructor: "Randomly split. Yes, that's right. It's inherently this random. There's … a random element to it. Because when I split it into training data and validation data, I just … did that randomly. So, if I ran this whole thing twice, I might get a different result. But … on average it shouldn't change too much."

This discussion took about 2 minutes of class time, and 40 of the 41 students present in class participated.

Example 2: brainstorming

In autumn semester 2024, in a senior-level materials science class (22 students) on polymer structure and properties, in the introductory lecture discussion the history of polymer science, I presented an open ended question: "Pretend you are sitting in the driver's seat of a new car. Can you reach out and touch something that's are not plastic/polymeric? If so, what?" Here, I don't look for correct answers, but read and comment on the students' responses.

- Student comment: "LED screen". Instructor, said aloud: "On my car, that's plastic; maybe that's glass in some [cars]".
- Student comment: "rearview mirror". Instructor, said aloud: "That's actually a maybe because you might be touching a polymer coating like an anti-glare thing".
- Student comment: "cloth seat". Instructor, said aloud: "The cloth seat. I mean, I guess that's not a plastic, but that is synthetic [polymer]."
- Student comment: "Seatbelt buckle". Instructor, said aloud: "Yeah, there's one!"

- Student comment: “The tracks of the seats”. Instructor, said aloud: “Oh, the tracks of the seats! So that's a good one. Although, are you touching the metal, or are you touching the polymer [containing] paint that's on top of it?”

In this case, the discussion took about 2 minutes and 20 of the 22 students participated.

Example 3: sketch responses in a large class

In autumn semester 2024, in a sophomore-level introduction to materials science class (307 students), I asked the students to make a sketch of the microstructure of a hypoeutectic alloy just below the eutectic temperature and showed the stream of student responses. As above, I picked a few of the student responses and provide commentary, as I did so, new responses come in that incorporated some of my comments. In this case, there are some joke responses (*e.g.*, sketching smiley faces), but nothing especially inappropriate. This took about 1 minute of class time and 133 of the 262 students present in class participated.

As displayed by the examples, the types of questions I use and feedback I provide in these anonymous discussions is relatively similar to what one uses in out-loud in-class discussions. A question or discussion takes 1-3 minutes and there are usually 1-2 questions per class period. However, a relatively large fraction of the class participates, even though no points are awarded for the activity. I find the discussions seem more efficient and robust (with more ideas put forward more quickly, and less pauses) in the anonymous TopHat format than my prior experiences with typical discussions. Interestingly, in Autumn 2023, I accidentally set a certain discussion to not be anonymous. After one student responded to the discussion, showing their name, the rest of the class seemed to hesitate, and I did not get further participation. Noticing this, I switched the discussion into anonymous mode, and the discussion proceeded as it normally had in the rest of that class. It is important to note that I did not measure the number of responses quantitatively or perform an experiment comparing methods in a controlled setting.

Conclusion

As shown in my examples above, the technique of hosting anonymous discussions requires very little preparation on the part of the instructor and a modest amount of class time, while it allows the instructor to get an up-to-date assessment about the thinking of many of the students. The anonymization lets students participate more freely without having to attach their name/identity on something that they fear may be wrong. Popular software such as TopHat can facilitate anonymous discussions while retaining the ability to later connect student names with responses; using this approach, I have not experienced significant issues with inappropriate student responses. Overall, I have found anonymized discussions to be an effective tool for encouraging class participation in both small and large classes from the sophomore through senior level. These issues can be explored in detail in future work by comparing anonymous and non-anonymous settings and using student surveys about their perceptions of the classroom environment and efficacy of the technique.

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