Benefits of a Low-Stakes Show and Tell Session in Biomedical Engineering Design

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Obtaining valuable feedback from various sources in engineering design is a critical part of the design process. Within our design curriculum, teams obtain feedback from their faculty advisor (on written and presented work) and peers (on presented work) at two points each semester: five weeks into the semester in a classroom presentation and at the end-of-semester poster session. Their peers are generally hesitant to offer comments during the classroom presentation, and the poster session comes too late to be useful. To take advantage of the vast array of student experiences, we devised a low-stakes Show and Tell session and placed it in between these presentations to introduce another opportunity for peer-to-peer feedback, though in an ungraded setting. The session followed a speed dating format using elevator pitches: teams quickly demonstrated their prototypes, specified a call to action, and received immediate verbal feedback from other teams. This structure was evaluated with an online survey, and questions were categorized by peer feedback, communication, format, and motivation for progress. Overall, students found the Show and Tell session to be beneficial to their design experience. Their calls to action were answered, and students directed their peers to new resources and ideas. The speed dating format was particularly valuable to sophomores and juniors. While the response of senior students was largely positive, several areas for improvement were identified. The Show and Tell will continue to serve as an important activity for peer interaction in our design curriculum.

Introduction

As design is the foundation of engineering, our Biomedical Engineering (BME) students at the University of Wisconsin-Madison design, build, and test solutions to real-world biomedical problems in teams of four to six members for five semesters in the BME curriculum. In the fall semester, teams either consist of sophomores and juniors or are composed completely of seniors. Every semester, students deliver two presentations to their instructors and peers. The preliminary presentation is an oral, slideshow-style presentation to a subset of the design teams five weeks into the semester. The purpose of this session is to obtain feedback related to the problem, background, design ideas and evaluation, and semester plan. The final poster presentation is open to the public and showcases all BME Design teams' resulting products. During both, students must provide written peer feedback. Furthermore, many students choose to provide supplemental verbal feedback, especially while making rounds at the final poster presentation. Teams found fellow students' suggestions to be uniquely valuable, but in the case of the final poster presentation, this feedback came too late to be useful. Additionally, our Assessment Committee, which reviews the work output from the spring BME Design courses annually, has noted that teams often run out of time in the semester for thorough testing, so it would be beneficial to incentivize them to prototype sooner [1, 2] . In response, we devised a low-stakes Show and Tell session which occurs semesterly between existing presentations to capitalize on our students' aptitude for providing valuable verbal feedback. Thus, the Show and Tell's intended outcomes were threefold: first, provide a formal yet ungraded opportunity for peer-to-peer feedback; second, further the achievement of ABET Outcome 3: communicate effectively with a range of audiences through the repetitive delivery of an elevator pitch; third, drive teams to prototype earlier in the semester to enable more robust testing and iterative design.

Various forms of peer-to-peer learning hold many advantages such as to learn by teaching in the case of tutoring [3] and to increase student performance, attendance, and retention using small group peer-led team learning environments and other forms of peer engagement [4-5]. Peer-peer environments have also resulted in higher quality and more meaningful feedback from collaborative team peer reviews as compared to individual peer reviews in design [6], a deeper understanding of the design processes [7], and building trust as well as improving outcomes when utilizing calibrated peer review in engineering design [8]. Ultimately, learning is best achieved when you create a sense of community in the classroom [9]. Thus, the Show and Tell represents a peer-to-peer feedback exercise by providing teams an opportunity to share their recent accomplishments with fellow classmates and obtain tailored yet diverse feedback on their first generation designs and prototypes. Moreover, the Show and Tell offers students a chance to develop their skills in quickly evaluating designs and providing constructive and concise feedback from their unique perspective.

To our knowledge, this format has not been described or evaluated previously. Though elevator pitch and peer-to-peer feedback activities have been implemented or encouraged by authors in the engineering education literature, their formats and goals are distinct to those reported here. The closest example comes from a publication by Mattucci and colleagues [10] in which the authors describe an end-of-semester poster session for first-year engineers. Students were required to craft feedback for two design teams and then present it to them. Two of six team members had to be at their poster at any time, but all students rotated during the 36-minute session. Additionally, teams that provided the most valuable feedback, as decided by their peers, earned bonus credit. Another publication detailed an end-of-semester elevator pitch activity in a telecommunication engineering course for second-year students where the goal was to help students synthesize course material and improve oral communication [11]. Two other examples in the engineering education literature focus on the entrepreneurial training that elevator pitches can provide [12, 13], and finally, elevator pitches have been proposed as a method to increase inclusion, teamwork, and skills of global communication [14].

Here, we present a detailed description of the novel Show and Tell format and share the results of an optional anonymous survey (determined to be IRB exempt) asking students to evaluate the utility of the session, highlighting which of the session's features were essential to the event's success and those which could be improved.

Show and Tell Format

The Show and Tell session occurs midway between the preliminary presentation and the final poster session. Teams gather in the same groups as the preliminary presentations with eight teams per group; groups are at the same project level–either all seniors or all sophomore/junior hybrid teams. Maintaining the preliminary presentation groups is a conscious choice to ensure students in the Show and Tell session are already familiar with other teams' project background statements and initial ideas.

The students are instructed to bring only their current prototype and/or representation of their final design. No slides, posters, or other auxiliary materials are allowed. To maintain a low-stakes environment, involvement is not graded. However, the session is moderated by an

instructor and follows a speed-dating format. Teams are split in half so that half of each team presents and the other half rotates around the room listening to pitches and providing feedback. In the sophomore/junior rooms, at least one sophomore student and one junior student start with the elevator pitch to guarantee mixed-level small groups. At the end of the allotted time for each pitch and discussion, the instructor asks the students who are providing feedback to move to the next team giving a pitch. Once each group rotates through all of the pitches, teammates switch roles to ensure all students present and all provide feedback.

Each elevator pitch is 60 seconds and comprises four key elements: 1. What is the problem?; 2. What is the solution and value?; 3. What progress has been made? What are the major milestones?; and finally, 4. Call to action: What help or direction do you need? Groups are given five minutes total for the pitch and discussion before switching to the next team. Therefore, at most, 40 minutes are spent on the first and second rotations each, leaving 40 minutes at the end of the two-hour class time to follow up with their teammates, classmates, and instructors regarding key takeaways.

Results and Discussion

The Show and Tell was evaluated through a survey, which received a 54% response rate from nearly 300 students across 64 design teams. Students commented that the session pressed them to prototype sooner than they had planned; their peers knew of helpful resources of which they were unaware; and their peers gave suggestions they had not considered. The exercise proved to be useful for the majority of the senior teams and very useful for nearly all sophomore/junior teams. These results are presented and analyzed more thoroughly in the following subsections: Peer feedback, Communication, Format, and Motivation for progress. Finally, after these subsections, we share student comments and suggestions for improvement from an optional and open-ended question at the end of the survey.

Peer feedback

The first objective of the Show and Tell was to provide an opportunity for the students to learn from each other. When the students were asked to select on which topics their team needed advice for their call to action, the top three identified areas were, in order: specific design consideration, fabrication methods, and testing plans. On average, the students set out to achieve feedback on two of these areas. At most, one student identified five topics in their call to action. Two of the three students who selected ‘Other’ wrote they were looking for advice on three-dimensional modeling. Further, 93 percent of students found their peers’ feedback helpful in at least one area (independent of whether or not the student sought feedback in that area), and students indicated they received valuable feedback on two topics on average. Several of those who did not select any areas on which their peers provided valuable feedback left optional comments saying there was not enough time to explain the project to gain in-depth feedback.

Comparing the call-to-action topics with the areas in which their peers provided valuable feedback in Figure 1, we observe that, for six topics, the proportion of students who sought feedback nearly exactly matched the proportion who obtained valuable feedback (i.e., these points sit near the line of unity). The other three topics (specific design consideration, fabrication

methods, and electronic or software element of your design) landed farther beneath the line of unity, between eight and 13 percent below, indicating that students' wishes for feedback in these areas were not fully met.

Though possible reasons for these deficits were discussed by students only briefly in the survey's optional text responses, we suspect they can be partly attributed to the project-specific nature and advanced level of the calls to action on these topics. Students may have required more project-specific context or brainstorming time to provide valuable feedback to their peers, though this is contrary to the purpose of the Show and Tell. Some of the deficiency may also be a result of the time-restricted communication, as described in the student commentary presented in the previous paragraph. The presenting students may have had insufficient time to explain their needs in enough detail, or it is possible that students were not effectively describing their project and/or needs. The authors also acknowledge that students may need additional training on these three topics, in particular, as part of the curriculum to improve feedback. Challenges posed by the format are discussed in greater detail in the *Format* subsection.

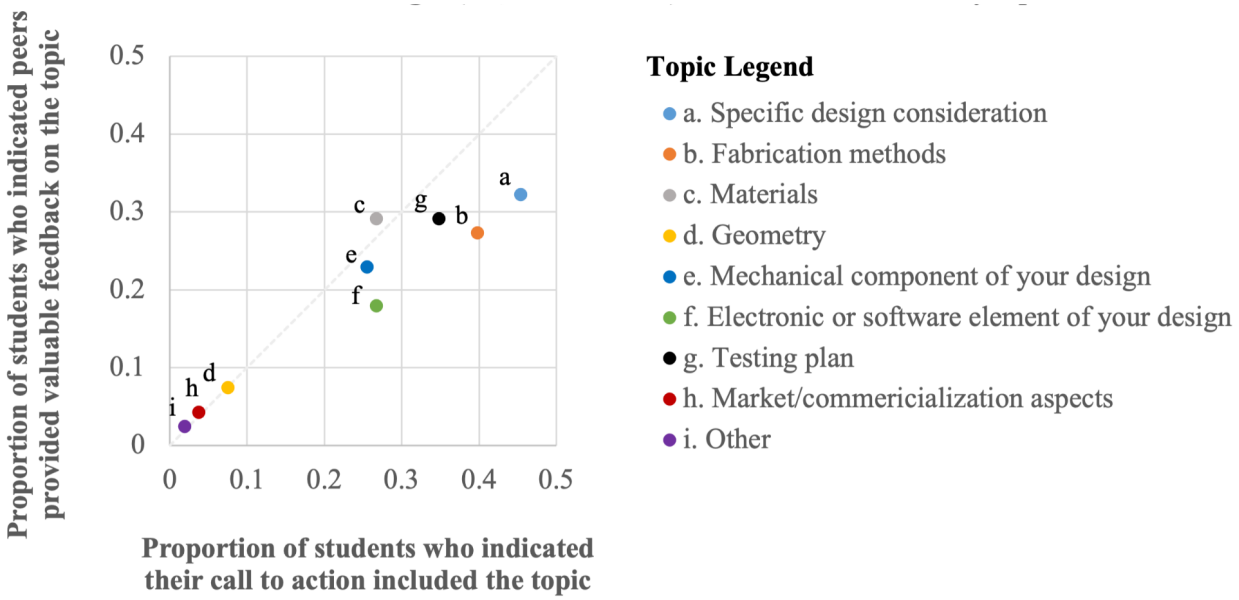

Figure 1. Relationship between feedback sought (i.e., students' call to action topics) and the feedback they received by topic. The students were asked: "Call to action: What was your team seeking advice about, check all that apply." Options given to students are listed in the figure legend. They were then asked: "On which topics did your peers provide valuable suggestions, check all that apply." The proportion of responses for each topic were plotted to show the most common responses and the relationship between them. The dashed line represents the line of unity. Each point that falls along the line of unity indicates that feedback on that call to action topic was received at a proportion commensurate with the proportion at which feedback was requested on that topic. For some topics, like geometry and market/commercialization aspects, few students sought feedback. Contrastingly, for topics like fabrication methods and specific design considerations, nearly half of respondents requested feedback. Overall, 93% of students

said they received valuable feedback from peers on at least one call to action topic, even if it was not one on which they originally sought feedback.

A paired evaluation of the responses is required to fully understand whether or not students received the feedback they requested. For example, 58 percent of students who requested feedback via their call to action on a specific design consideration indicated that they received valuable feedback on this topic, suggesting that 42 percent of students who requested this feedback did not feel they received it. However, 11 percent of students who did not originally request feedback on a specific design consideration indicated they did receive valuable feedback on this topic. Across all topics, excluding 'Other,' 59 percent of students received the feedback they desired on average, while eight percent obtained valuable feedback on a topic they did not originally identify as an area of need. The same analysis decomposed by grade level revealed that the proportion of students who received valuable feedback on a topic they did not specify in their call to action was nearly the same across grades (sophomores: seven percent, juniors and seniors: nine percent). However, 67 percent of sophomores indicated they received valuable feedback on their call to action topics on average across all topics, while 59 and 51 percent of juniors and seniors, respectively, felt the same.

Overall, sophomore students found their peers' insights the most valuable in answering their teams' calls to action (Figure 2). Juniors and seniors also found it to be valuable, though slightly less than their younger peers. This is perhaps related to the fact that sophomores were able to obtain feedback from juniors, whereas seniors were learning from each other and have been through biomedical engineering design at least four times already. Still, the majority of the students learned from their peers and were able to iterate through their needs over the session.

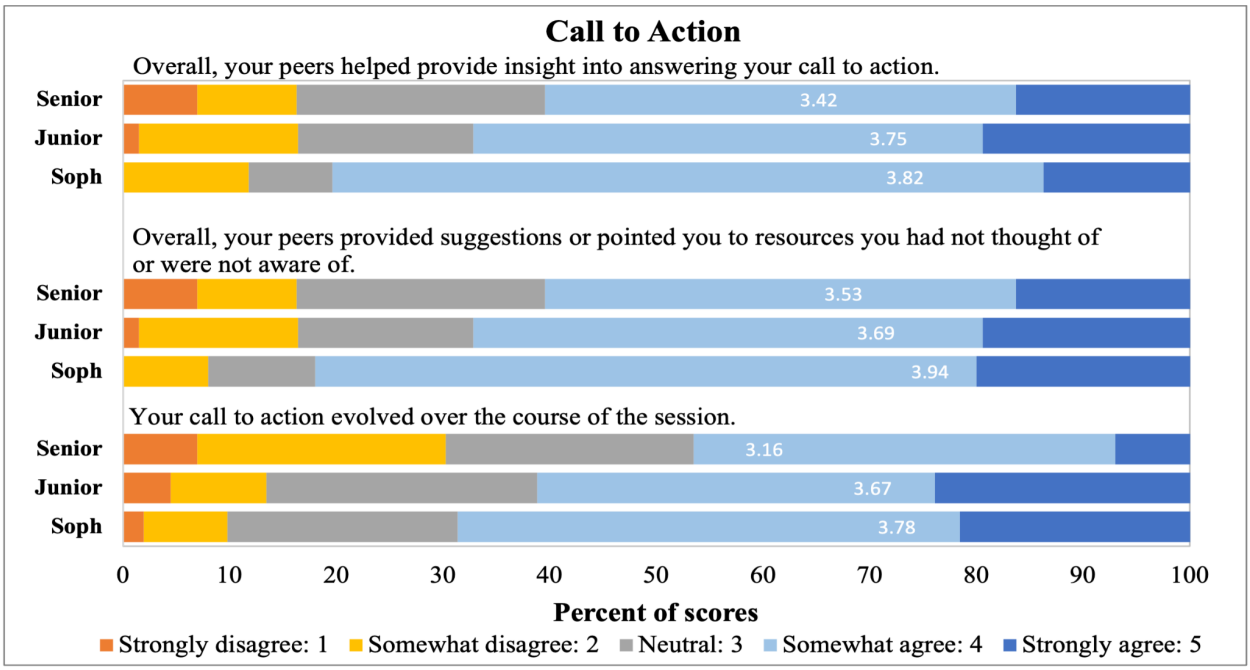

Figure 2. Students' evaluations of their calls to action (mean reported as a numerical value).

Communication

The second objective was geared toward improving the students' ability to communicate. As shown in Figure 3, survey results show that students across all grade levels felt very well prepared to give the elevator pitch based on our guidelines and sample pitch videos. Furthermore, nearly all students felt their pitches improved throughout the event which can be attributed to the effective redundancy of the speed dating format.

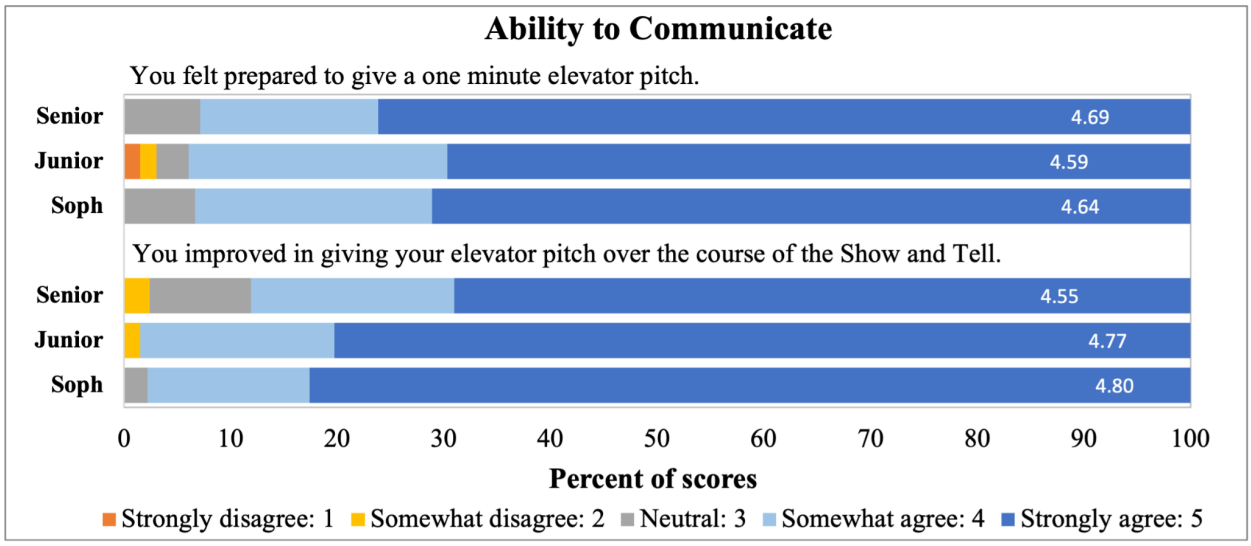

Figure 3. Students' evaluations of their elevator pitches (mean reported as a numerical value).

Format

In a one-way analysis of variance, grade level was found to have a statistically significant effect on students' opinions of how useful the Show and Tell exercise was overall ($F(2,151)=12.71$, $p<<0.05$). Sophomores and juniors found the Show and Tell to be overwhelmingly useful with 96 and 92 percent of students ranking the question as a four or five (Figure 4). Interestingly, approximately 40 percent of the senior respondents ranked the overall usefulness of the Show and Tell at a three (neutral) or lower. A Tukey's Honest Significant Difference post-hoc analysis revealed that both sophomores ($M=4.46$, $SD=0.131$) and juniors ($M=4.41$, $SD=0.109$) scored this survey question higher than seniors ($M=3.62$, $SD=0.137$) at a significance level of 0.05. Several comments written in the survey on optional open-ended questions revealed insights that might explain the imbalance seen between grade levels. Here is one student's description of the challenge:

> *I think that by the [senior] level that all the call to actions were complex...By senior year, we all know the general ideas and concepts for design and prototyping so I think the questions were harder than in previous years. This also made it so most of the time, students couldn't help my group and I couldn't help other groups because problems were too specialized.*

Another student expressed a similar view and offered a potential solution:

> *I feel as though once we get to [be seniors]...those of us working on a more mechanical project for example don't have as much electronics experience and can't give a ton of feedback to those with electronics based projects... that are very complex at this level ... It may be helpful to group projects by more electronics, mechanical and tissue related to keep groups that have more similar projects together instead of grouping by advisor.*

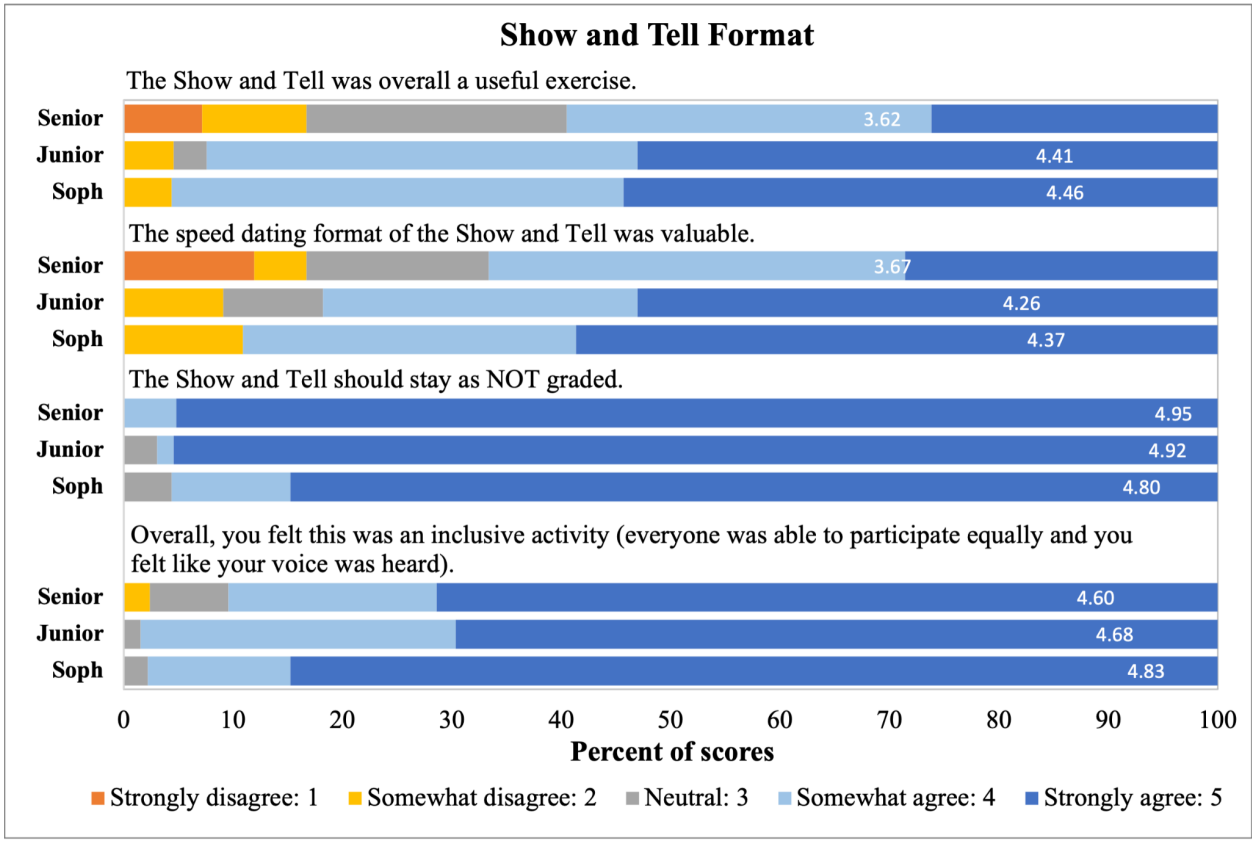

Figure 4. Students' evaluation of the format (mean reported as a numerical value).

A statistically significant difference in students' scores on the effectiveness of the speed dating format was also found using a one-way analysis of variance ($F(2,151)=5.70$, $p=0.004$). A post-hoc analysis showed that seniors ($M=3.67$, $SD=0.163$) found this format to be less valuable than both sophomores ($M=4.37$, $SD=0.156$) and juniors ($M=4.26$, $SD=0.130$). This discrepancy between grade levels is similar to the results of the first question shown in Figure 4, though slightly smaller in magnitude. Of the sophomores and juniors, 89 and 82 percent found the format to be beneficial, while only two-thirds of seniors shared this view. We believe this result may also be due to the complex nature of senior-level design projects.

The third format question shown in Figure 4, "The Show and Tell should stay as NOT graded.", received a particularly high average rating from all three student groups. Over 95 percent of juniors and seniors and 85 percent of sophomores strongly agreed. In an open-ended and optional

question at the end of the survey, students were given the opportunity to share what they liked about the Show and Tell session. Comments were left by 38 percent of the respondents, and of these, 23 percent suggested that the unbuttoned environment lended to better conversation and was an important feature of the Show and Tell. This commentary was identified with language such as *casual*, *informal*, and *ungraded*. For example, one student's response illustrates the sentiments of many:

> *I liked that it was not super formal because this allowed for an easier flow of communication and ideas between groups. Everyone was extremely supportive and asked valuable questions to help get us thinking. Unique ideas were brought up that my group never had thought to do before.*

In the fourth question, students were asked to focus on inclusivity and the ability to have their voice heard. Responses were predominantly positive: the ratings for all grade levels averaged over 4.5 out of 5. The speed dating format is inherently inclusive since all students play both the role of the presenter and the one who offers feedback. Additionally, having small groups rotate one at a time better includes students who identify as introverts or who are shy as opposed to speaking in front of the whole group. Students who may not normally feel comfortable presenting to a large group are more inclined to participate when the groups are smaller and the stakes are lower [15].

Based on these results, particularly the discrepancy in utility between senior and younger students, the format suggested by the student, i.e., grouping teams by project focus (e.g., biomaterials, biomechanics, bioinstrumentation, and imaging), merits further exploration. Conducting the Show and Tell in these groups may help senior teams give and receive feedback at the technical level desired. A further extension of this setup would be to pair teams within project focus areas. These teams would provide targeted feedback to their partner team throughout the semester, including at the Show and Tell. This format may lend itself to deeper discussions about teams' calls to action without sacrificing the informal and inclusive nature of the Show and Tell, which was valued by students across all grade levels. These approaches are feedback-oriented derivatives of the group-to-group and pair-to-pair peer learning strategies employed in engineering labs [16].

Motivation for progress

Students were also asked to evaluate how the Show and Tell session affected the prototyping phase of the design process. When asked if this exercise prompted them to prototype earlier than they otherwise would have (Figure 5), students in each grade level responded similarly to the first format question in Figure 4. There was an imbalance in the response between seniors and their younger peers. By this point in their engineering education, senior students have been through the design process at least four times and have likely developed stronger project management skills. This might explain why seniors did not agree as strongly as sophomores and juniors when asked if the Show and Tell encouraged them to prototype earlier. From an instructional and historical standpoint, teams expressed urgency in their weekly meetings with instructors to have a prototype to show, whereas in years prior, teams tended to be less proactive. Overall, the authors believe that the Show and Tell session effectively encouraged students to

create physical and/or virtual prototypes earlier in the semester, achieving one of the goals of the course instructors.

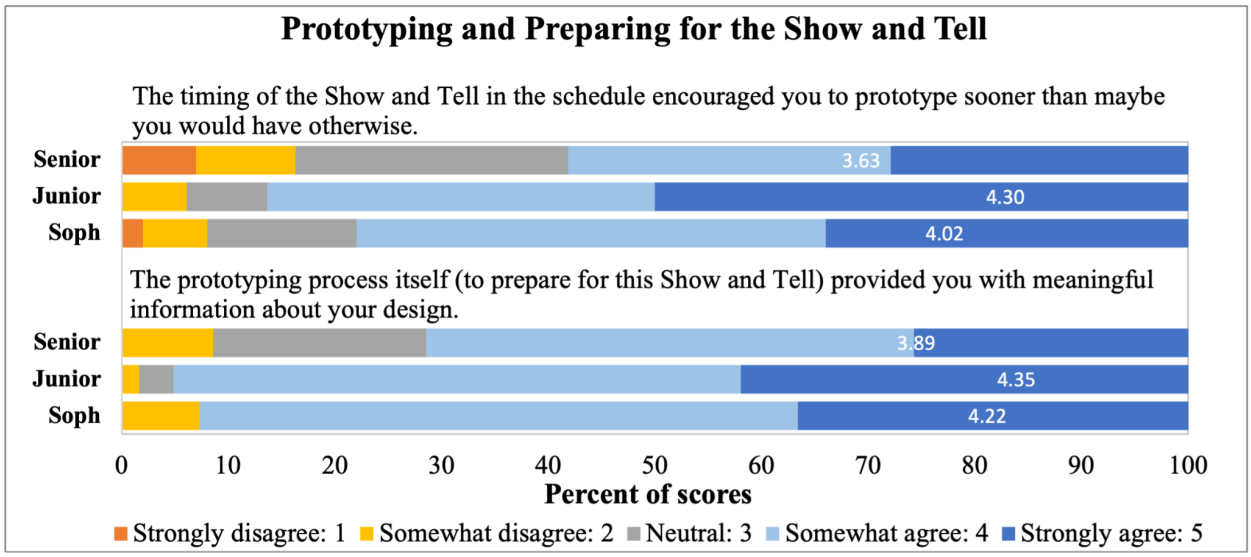

Figure 5. Students' evaluation of the prototyping process (mean reported as a numerical value).

Additionally, students were asked if the prototyping process itself provided their team with meaningful information about their design. Results shown in Figure 5 demonstrate that most students did find the prototyping process to be beneficial to the design process. However, seniors again had the lowest average rating as opposed to sophomores and juniors. A one-way analysis of variance revealed a statistically significant effect of grade level on students' views of whether the prototyping process provided meaningful design information ($F(2,135)=4.36$, $p=0.015$). A post-hoc analysis, using the same method described above, found that juniors ($M=4.35$, $SD=0.096$) scored this survey question higher than seniors ($M=3.89$, $SD=0.128$) on a statistically significant level, but no statistically significant differences in scores were seen between other pairings.

These results should be investigated further to understand what causes the negative drop between third- and fourth-year design students. One possible cause of this result is that the advanced nature of senior capstone projects may lead to more difficulty in prototyping. A future study should include a series of follow-up questions for those students who gave a score of neutral or lower to better understand what factors contribute to their rating. This data will be useful in helping instructors to better support students in prototyping these projects and to ensure teams are extracting relevant and useful information from this process and the resulting prototype.

Final student comments

In the last open-ended question at the end of the survey, students were given the opportunity to share what improvements they thought could be made to the Show and Tell session for future semesters. Of the 66 students who left a substantial comment (unsubstantial comments were excluded if they did not indicate an improvement, such as *N/A*, *Nothing*, and *None*; n=7),

44 percent suggested more time be added to each interaction with another team. When asked for their desired Show and Tell time, students were able to select a value between one and ten minutes. Results are plotted in Figure 6. The average desired Show and Tell time was 5.88 min which is slightly greater than the current allotted time (5 min). A small group of students held the opposing view and commented that their teams ran out of topics to discuss before time expired. We found that these students are the same ones who felt their calls to action were not answered well or were too complex for discussion. As one senior stated, "there is no way for students to view 500 line software to help us debug it." In the end, the timing was nearly right for the majority of the students, and future iterations allowed one more minute after the 5-minute timer so that groups could wrap up their immediate discussion.

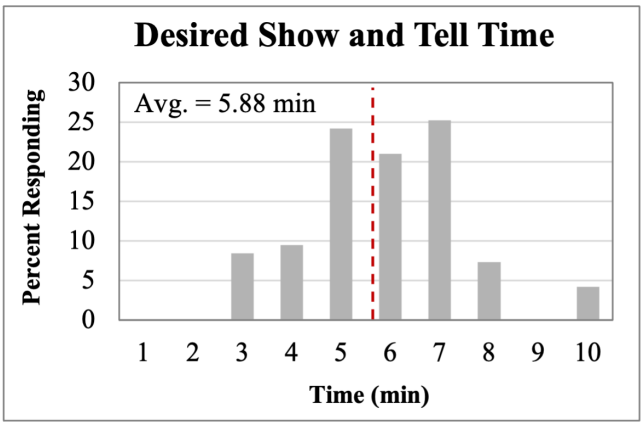

Figure 6. Students' desired Show and Tell length per interaction. Students were asked to choose how long each round of the exercise should last between one and 10 minutes. Out of 95 responses to this question, the average time was calculated to be 5.88 minutes or 5 minutes and 53 seconds.

Conclusion

Here we present the student response to an innovative peer-to-peer feedback activity, a Show and Tell in a design course, that was crafted in response to their feedback asking for more interaction between teams before the end-of-semester poster session. Overall, students found the Show and Tell session to be a valuable part of their design experience, particularly sophomore and junior students. The timing of the event compelled students to prototype sooner than they otherwise might have. Students across all grade levels felt the exercise was inclusive and highly valued the low-stakes format of the Show and Tell session. The quick and repetitive nature of the speed dating format allowed for improvement in pitching their design and evolution in teams' calls to action.

Sophomores found the format to be the most effective, followed by juniors and seniors, respectively. Some students felt the calls to action at the senior level were too complex for the short timeframe or the narrow expertise of their peers. These insights suggest that a modified session format for the senior students should be developed, prototyped, and iterated over future semesters. One such change was implemented during the online learning semesters of the

pandemic where the Show and Tell was adapted into an online discussion post in Piazza. Here, each team (all classes mixed together) could upload a representative figure or image of their prototype to assist with their call to action. Posts were also tagged with a category (instrumentation, mechanics, materials, imaging, optics, sciences, fabrication, testing, marketing) to facilitate matching expertise with the problems. Each student was required to individually respond to another group's post.

While our Biomedical Student Advisory Committee found that this format was helpful in that more time was allotted to provide feedback (one week) and they could use resources to help craft their response, it was reported to be overwhelming given the number of projects and difficult to demonstrate their call to action and prototype within a graphic. Plus, they missed the back and forth verbal communication and interaction. As a result of this feedback, this online only method is no longer being pursued; however, future iterations might employ a combination of an online post followed by an in person session grouped by project call-to-action category allowing cross-class interactions. Similarly, this might be done where the seniors are the ones answering the calls to action in an open session, thus providing an opportunity for younger students to learn from their more experienced older peers.

Overall, instructors agreed that the Show and Tell exercise led to final products that were more sophisticated and innovative than in previous years as more design iterations could be completed and more testing took place. Though this feedback is subjective, it shows promise that a low-stakes peer-to-peer feedback activity placed in the middle of the semester has tangible effects on the quality of design deliverables in addition to developing students' ability to pitch their designs and provide feedback. Overall, the survey gave students a platform to voice their opinions on the design curriculum, and the results presented here are undoubtedly valuable in understanding how design teams across three grade levels valued a low-stakes exercise.

Acknowledgements

The authors would like to thank the Assessment Committee, members of the Design Faculty for helping in establishing, implementing and supporting the Show and Tell activity and the Biomedical Student Advisory Committee for providing real-time feedback. The authors would also like to thank all of the students in BME Design for providing valuable feedback both in the survey and in person.

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