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Evaluating Teaching Culture Change within a Mechanical Engineering Department

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1. Introduction

Engineering education is changing rapidly, particularly as contemporary engineering problems require increased curiosity, experimentation, and deeper understanding and as efforts to diversify the demographics of engineering students have intensified [1], [2]. Academic engineering departments must be prepared to adapt to these changing environments and anticipate the future needs of their diverse student body. Successful adaptation often requires meaningful changes in the broader departmental culture [3], [4]. Culture, within an organizational context, refers to the shared values and assumptions that provide context as to why organizations do what they do and focus on what they focus on [5], [6]. These values and assumptions inform desired behaviors, guide evaluation of behaviors, and ultimately become ingrained into the culture [7]. Challenging these values and assumptions can result in anxiety and defensiveness among organizational members because these assumptions provide stability through defining how employees should act and react [5]. To enact culture change, organizational leaders must understand the current values and assumptions that are not working and are not conducive to the new, desired cultural environment as well as demonstrate motivation and commitment towards the cultural change process [8]. Leaders must also introduce and incorporate new values and assumptions through a collaborative and participatory approach that enables organizational members to have autonomy, responsibility, and opportunities to provide and receive feedback [9].

Broader departmental changes within STEM have often been accomplished through efforts to promote change within pedagogical practices for undergraduate STEM courses and support and recognize educational innovation [10]. An established approach utilized in the improvement of undergraduate STEM courses is faculty development, which is aimed at providing faculty with broad pedagogical skills or motivation and resources for self-improvement [11]. Departmental investment in faculty development programs are key to enhancing the professional success and personal well-being of faculty [12]. Primary goals of faculty development programs include advancing new initiatives in teaching and learning and improving teaching and learning outcomes [12]. Faculty development researchers have extensively investigated different change strategies for helping faculty improve their teaching practices, with the most common being: (1) interventions by professional consultants and facilitators, (2) workshops, seminars, and courses, (3) mentoring programs, and (4) action research; additionally, these change strategies often involve shared responsibility and accountability among colleagues, last for at least one full semester, and are focused and concrete [13].

Many faculty development approaches utilize frameworks that focus on reflective teaching, aimed at encouraging individual faculty members to reflect on their teaching and improve their instruction [14]. By focusing on individual development, faculty members have more autonomy in decision making for their classrooms, empowered to use new pedagogical approaches and contribute to larger institutional change [11]. Common reflective teaching approaches include educating faculty members about various instructional possibilities, encouraging them to collect experimental data within their own classrooms, and enabling small

groups of faculty members to collaborate on pedagogical innovations [14]. These approaches enable faculty members to take a more active role in the change process by applying their knowledge and expertise; faculty developers/change agents often take a more facilitative role in providing feedback to faculty members and encouraging reflection [11].

Many of these strategies were utilized in our overarching efforts to achieve teaching culture change. Over a four-year period, our research team has engaged in a project entitled Teams for Creating Opportunities for Revolutionizing the Preparation of Students (TCORPS), which was funded by a National Science Foundation (NSF) IUSE/PFE: Revolutionizing Engineering and Computer Science Departments (IUSE/PFE: RED) grant. The broader vision of the grant project is to revolutionize the teaching culture of the Department of Mechanical Engineering (MEEN) at Texas A&M University into a bottom-up team structure where a sustainable process of incremental improvement in teaching is encouraged by leadership and the learning needs of the department's increasingly diverse student population are considered and fulfilled. Historically, this MEEN department has engaged in a somewhat static approach to teaching where there was very little change to the structure of undergraduate courses over the years, change was managed through a top-down approach, and innovation and experimentation were typically reserved for research. The research literature on changing STEM instructional practices has demonstrated the ineffectiveness of these approaches, such as top-down directives, as they do not address faculty members' implicit beliefs that impact their teaching decisions [4].

The primary approach of the grant team was to focus on faculty development and culture change to aid faculty members in their efforts to implement pedagogical changes and increase iterative and measured innovations in teaching [19]. The grant team implemented multiple activities throughout the four-year period with the objective of faculty development as a means to achieve culture change within the MEEN department [20]. Before initiating major project-related activities, pre-implementation interviews with faculty members were conducted to obtain a baseline assessment of the departmental teaching culture and inform the next stages of the grant research. The qualitative data gathered from these interviews were utilized to inform the construction of a series of climate surveys meant to examine the teaching and teaching innovation culture in the MEEN department as well as self-assessment of efficacy in teaching and teaching innovation.

One of the major activities undertaken by the grant team was a formalized faculty development process in which faculty-led, soft-wired, bottom-up teams engaged in experimental research projects focused on pedagogical innovation. To support the teams in their innovation-related efforts, the grant team led a recurring summer faculty development workshop series that provided the participating faculty members with training on skill areas that would help them become innovative in their teaching (e.g., innovation cycles, iterative experimentation processes, the psychology of teaching and learning, and measurement tools for evaluating effectiveness). The workshop structure aligns with other evidence-based pedagogical change approaches that advocate for the use of models that faculty understand, such as utilizing typical research practices for teaching [4]. Additionally, approximately monthly meetings with the cohorts and the grant team were scheduled throughout the academic year for the teams to provide progress updates and receive feedback and support.

2. Purpose

The purpose of this research paper is to examine the entire cycle of culture change evaluation within the grant and answer the question, "Did culture change happen within the MEEN department?". Ultimately, this review of our multiple research studies investigates whether these faculty development-related activities were effective in shifting the department's teaching culture to one that supports and champions innovation within teaching. Over the multi-year grant, the research team has gathered various sources of quantitative (e.g., climate survey results, a systematic rubric for evaluating teaching innovation proposals pre- and post-workshop participation) and qualitative (e.g., interview data, observational data from the project teams' coordination meetings) data. We report on 4 types of culture change-related assessments in the remainder of this paper.

3. Assessment 1: Interview Data (Pre- and Post-Implementation of Grant Activities)

In addition to the pre-implementation interviews that were conducted prior to the grant, the research team also conducted post-implementation interviews after the completion of the project to understand how faculty perceptions of the departmental teaching culture may have changed throughout the project's duration.

Method

Overall, 21 faculty members (13 in the pre-implementation interviews and 8 in the post-implementation interviews) from the MEEN department were recruited to participate in semi-structured interviews. Seven of the eight interviewees in the follow-up interview study participated in the initial interview study and all eight interviewees were involved in grant-related activities, with six engaging in teaching innovation projects. The pre-implementation interviews were conducted between February and May of 2021 and the post-implementation interviews were conducted over the summer of 2024. The interviews were conducted and recorded via Zoom and took place with one participant and either one or two interviewers from the internal evaluation team. A variety of job types were represented in the participant sample, specifically tenure-track/tenured faculty, instructional professors, professors of practice, and lecturers. Instructional professors and professors of practice both exist under the larger umbrella of academic professional track (APT) faculty (those that are non-tenure, primarily teaching-focused).

For the pre-implementation interview study, the interview protocol included a series of planned questions that focused on the positive and negative aspects of teaching in the department, innovating teaching in the department, personal challenges and successes with teaching, and other teaching-related experiences, preferences, and ideas. Audio transcripts and interviewer notes were analyzed via a thematic analysis approach. For the post-implementation interview study, many of the same questions were asked in the post-implementation interviews as in the pre-implementation interviews. Additionally, questions pertaining to the impact of the NSF RED grant were asked, such as how the grant has impacted faculty members' expectations and feelings about teaching, whether the grant has impacted the teaching culture in the department, and how the grant may have impacted their efficacy for teaching and teaching innovation. The predetermined interview questions for both studies are included in the Appendix. For both studies, audio transcripts and interviewer notes were analyzed via a thematic analysis approach. During our analysis, we felt that our acquired sample sizes were adequate as the goal

in qualitative research is reaching saturation (i.e., enough data is collected and no new themes or insights are emerging from further data collection) rather than getting the most participants.

Results

Culture Assessment from Pre-Implementation Interviews

Overall, faculty participants had positive feelings regarding teaching and teaching innovation. Participants appreciated the opportunity to interact with students and they also viewed teaching innovation as an important component of teaching. However, participants still communicated an apprehension to implement teaching innovations. First, there was no formal structure within the department to support a desired culture of innovation and experimentation in teaching. The underlying assumptions regarding curriculum within MEEN was that curricular changes needed to be comprehensive and governed by upper-level administration rather than a bottom-up process of curricular change that involved individual faculty members. There were also oft-repeated messages about research being more valuable, which is a similar message perpetuated across academia and especially at R1 universities. Faculty members have many competing priorities, such as research or high teaching loads, and their pre-implementation beliefs were that teaching changes would require a significant amount of time and effort that is ultimately not recognized or valued by the department leadership. As a result, faculty members prioritized their research responsibilities over their teaching responsibilities or refrained from making any significant pedagogical changes to their already demanding teaching loads. Lastly, as expected, many faculty members were resistant to change, believing that their teaching methods are good and do not need to be modified or that their class is so specialized and unique that changes are not possible.

Culture Assessment from Post-Implementation Interviews

The post-implementation interviews indicated noticeable changes in the departmental teaching culture after the conclusion of the RED grant. Participants acknowledged that there was a significant increase in the amount of positive and constructive discussions around teaching and teaching innovation, with more faculty members getting involved as well. A major contributing factor to this change was the introduction of the Teaching Community of Practice (TCOP) within the MEEN department, which provides a consistent space for faculty members to discuss topics related to teaching and teaching innovation. Communities of practice have been demonstrated to be instrumental in promoting both individual and collective change in teaching practices [4], [10], [11], [15], [16]. The TCOP was created by faculty who were engaged with the RED grant to continue the conversation and lead it themselves (instead of by the grant team). Participants also stated that the department is more supportive and encouraging of teaching innovation and that departmental leadership is providing more resources to support pedagogical improvements, such as discretionary funding and course releases. Faculty members have been supportive of the changes, while new norms around appreciation of teaching innovation have been ingrained among newer faculty members. Additionally, there has been a positive mindset shift among faculty members as seeing teaching innovation as less overwhelming and more manageable through small, incremental changes.

4. Assessment 2: Climate Surveys

Method

The participants consisted of faculty members (tenure-track, tenured, and academic professional track) and graduate students in the MEEN department. The online climate survey was distributed 10 times between June 2021 and June 2024 (roughly 3 times per year) to the entire department (including staff members) via Qualtrics. The content of the surveys included the following topics for teaching and teaching innovation: means efficacy (i.e., are there sufficient resources), self-efficacy (i.e., do I believe that I am capable of this?), competing priorities (e.g., do I have enough time?), department readiness for change (i.e., perceptions that the department is committed to the change and able to accomplish it), department climate issues (e.g., do people feel fairly rewarded for teaching efforts), individual readiness for change (i.e., am I committed to the change?), and assessment of time spent on different in-class activities. Additionally, some questions were included for individuals who engaged in the summer workshop series as a way to evaluate whether they believe they have applied their learning to the classroom. For these survey areas, participants indicated their level of agreement using a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Other survey areas involved participants providing the percentage of time they spent in class on different activities (e.g., lecture, small group discussion, videos) and ranking both their and the department's readiness to change when thinking about teaching innovation (on a scale of 0-10, with 0 being "no thoughts about it" to 10 "taking action, such as planning activities").

Respondent totals per survey distribution round are shown in Table 1. Ultimately, the respondent totals were low, but respondent totals did stay somewhat consistent between Rounds 3-8. Efforts were made to increase the respondent totals, such as sending reminder messages to non-respondents, enabling respondents to go back to the survey if they could not complete it in one sitting, attending faculty meetings to encourage them to complete the survey, and distributing the survey to only faculty members and graduate students who either taught or acted as a teaching assistant for undergraduate courses. A low number of participants per survey round, however, was not completely unexpected as the survey was distributed electronically, an incentive could not be offered, and there were concerns regarding survey fatigue.

Survey Round	1	2	3	4	5	6	7	8	9	10
Number of Respondents (n)	35	29	20	18	18	19	17	15	9	7

Table 1: Participant Totals per Survey Round

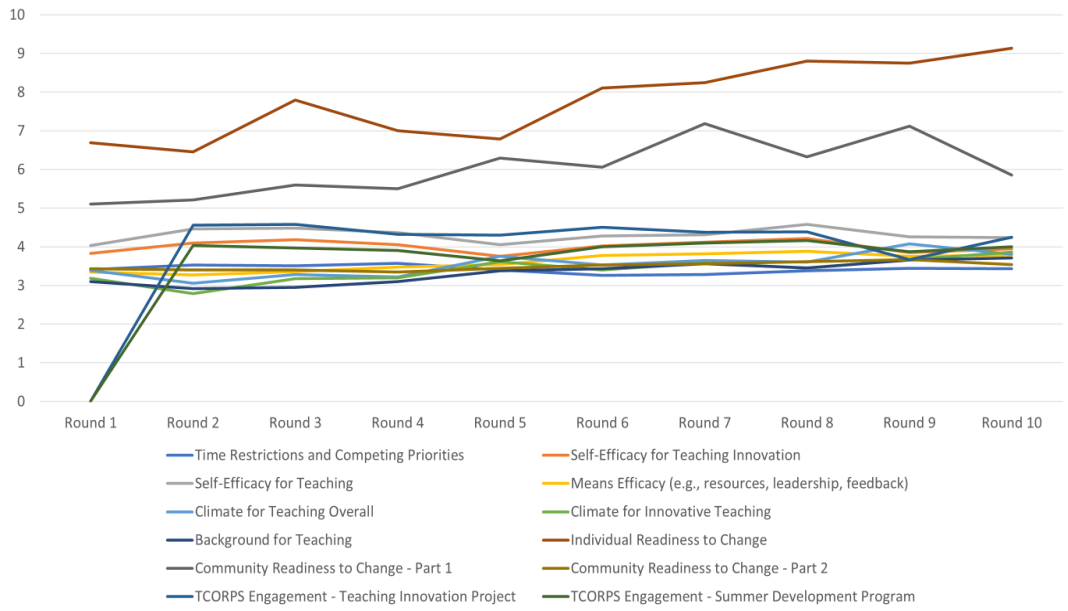
Results

Figure 1 shows the change in the means of each of the survey areas across Rounds 1-8. There are no Round 1 means for the TCORPS engagement areas as these survey questions first appeared in Round 2 (the first round administered after the completion of the first iteration of the summer workshop series). While the goal was to examine within-person change over time in survey responses, we unfortunately did not have a sufficient sample size to conduct those

analyses. Ultimately, we decided to compare the change in means of each of the climate survey areas over Rounds 1-8. Rounds 9 and 10 were not included due to very low survey responses.

Although there are some inconsistencies within each trend, overall, there appears to be a trend of positive change in several survey areas. There were increases in the averages over time for Self-Efficacy for Teaching Innovation, Self-Efficacy for Teaching, Means Efficacy, Climate for Teaching Overall, Climate for Innovative Teaching, Background for Teaching, Individual Readiness to Change, Community Readiness to Change (both parts), and TCORPS Engagement - Summer Development Program. The results rendered us unable to utilize any tests of significance or make any definitive claims, but over time, it appears that respondents felt more capable of engaging in effective teaching practices and innovating their teaching, slightly felt that there were more resources available for support and that the climate for teaching had improved and were increasingly contemplating teaching innovation and moving towards taking action.

Figure 1: Change in Means of Each of the Survey Areas



5. Assessment 3: Assessment of Innovation Proposals Pre- and Post-Summer Workshop

Based on the substantial literature on institutional change, we investigated the effectiveness of a different strategy based on assisting faculty with curricular or pedagogical changes through an innovation training workshop series and the creation of a learning and sharing community of practice so that they can self-regulate their teaching innovations. We introduced a workshop on educational innovation, to improve faculty approaches to curricular or pedagogical changes. This included the initiation of educational innovation teams and the framework to encourage innovation. Faculty were asked to create groups and propose changes to their curriculum or pedagogy before the innovation training workshop. They were asked to resubmit their proposed changes after the workshop. We evaluated the changes in their approach

by scoring their proposals based on a rubric that was created for assessing the evolution of faculty's mindset and behavioral changes [17-18].

Method

To assess the impact of the innovation training workshops on faculty members' ability to plan and execute teaching innovations, the RED grant team designed a systematic evaluation process. This process involved collecting pre- and post-training innovation proposals from participating teams and scoring them using a detailed rubric. The rubric was designed to measure the progression of faculty's ability to articulate clear, measurable student outcomes, align their proposed activities with stated goals, incorporate lead and lag indicators, and track progress through iterative cycles.

A total of 9 project teams submitted proposals across the two workshop cohorts—4 teams in the 2021 cohort and 5 teams in the 2022 cohort. Pre-training proposals were collected before the start of the summer workshops, and post-training proposals were submitted at the conclusion of the workshop series. To ensure consistency and reliability in evaluation, each proposal was scored independently by 4 evaluators in the first cohort and 5 evaluators in the second cohort, following a rigorous scoring protocol.

Rubric for Evaluation

The rubric used to assess the proposals consisted of seven key criteria:

1. Goal Orientation – Whether the goal of the innovation was centered on measurable student outcomes.
2. Activity Alignment – The degree to which proposed activities aligned with the stated goals and leading indicators.
3. Measurement Indicators – Whether faculty identified clear leading indicators (predictive metrics) and lag measures (outcomes).
4. Tracking and Adaptation Plan – Whether faculty articulated a plan for tracking progress and modifying activities based on data.
5. Inclusivity – Whether the proposal addressed inclusivity in curriculum or pedagogy.
6. State Change Articulation – Clarity in articulating state change in the form of "From X to Y by When."
7. Iterative Approach – Whether the proposal adopted a sustainable, iterative approach to innovation.

Each criterion was scored on a scale of 0 to 4, with higher scores indicating greater proficiency.

Results

Figures 2 and 3 compare the pre- and post-training scores for each cohort. The data revealed that faculty in the second cohort showed greater improvement overall, likely due to modifications made to the workshop structure based on feedback from the first cohort. Specifically, the second cohort's workshop placed greater emphasis on measurable outcomes and incremental goal-setting using the proposed incremental innovation process [17].

Despite these improvements, scores for inclusivity (criterion 5) remained relatively low, suggesting that additional emphasis on fostering inclusive teaching practices is necessary in future workshops. Additionally, the post-training scores for the second cohort were consistently higher than those of the first cohort, indicating that the revised workshop structure was more effective in achieving the desired outcomes.

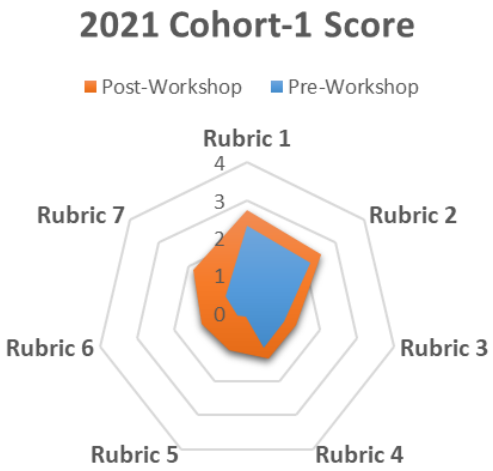


Fig. 2. Cohort 2021 Improvement
in Teaching Proposals after the Training

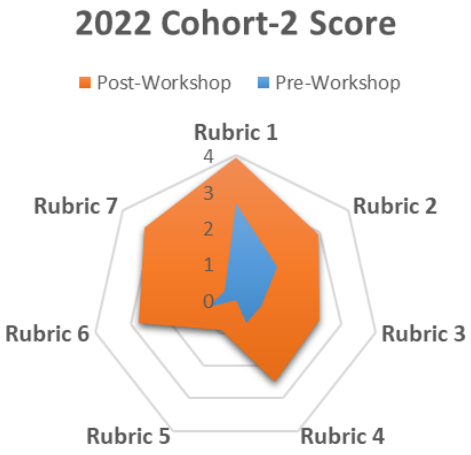


Fig. 3. Cohort 2022 Improvement
in Teaching Proposals after the Training

The results indicate that the innovation training workshops effectively improved faculty's ability to plan, execute, and iterate on teaching innovations, particularly in setting measurable goals and tracking progress. The innovation framework played a critical role in fostering a culture of continuous improvement. However, inclusivity remains an area needing further

emphasis in future workshops. The creation of the Teaching Community of Practice (TCOP) has provided a sustainable platform for ongoing support and collaboration among faculty.

6. Assessment 4: Observational Data from Innovation Project Team Meetings

At the time of the grant's inception, MEEN faculty and teaching assistants had a practice of regular (usually weekly, biweekly, or monthly) course coordination meetings, in which instructors of the multiple sections of the same course formed soft-wired teams (i.e., some people are in the group each semester, and some are in the group in some semesters, depending on their teaching assignments) to exchange ideas and synchronize class experiences across the different sections. During the summer workshop series, the grant team encouraged faculty to use the course coordination meetings to discuss their curriculum change project. The internal evaluation research team observed these course coordination and project team meetings to investigate whether the two types of teams (teams in the training cohorts and teams not in the training cohorts) discussed teaching and teaching innovation in different ways.

Method

Participants were 35 faculty members and teaching assistants (undergraduate and graduate) within the MEEN department; this included both tenure-track faculty and academic professional track faculty. These faculty members were either in teams that participated in the summer workshop series and were engaged in a pedagogical innovation project or non-treated course coordination teams. Some of the faculty members were involved in multiple teams, both treated and non-treated. Overall, there were four treated teams and six non-treated teams across three semesters. The research team conducted observations of course coordination meetings from treated teams (conducted either in person or via Zoom). Observations were completed by two graduate research assistants and 10 undergraduate research assistants. Observations included notes written *in vivo,* recordings of the meeting (audio or audiovisual), and transcripts generated from these recordings. Researcher notes included the content of the meeting, interactions and participation by group members, and impressions of the meeting dynamics. A high-level thematic analysis approach was utilized for analysis of the observation notes and transcripts, in which the research team developed themes that emerged as being important to the teams' discussions around teaching and teaching innovation.

Results

The internal evaluation team attended 4-6 coordination meetings per team, resulting in 50 meetings attended, and 2-3 pages of observation notes were generated per each observer.

Relevant Themes for Both Teams

The following themes emerged in both treated and non-treated teams. While these specific themes are shared among the two types of teams, the context and nature of the discussions differed.

Course Logistics

For non-treated teams, a majority of the discussions were centered around course logistics and the structuring of the different sections of a MEEN course. Faculty members

discussed their progress in the course and updated each other on what concepts they had taught from week to week. Members would review lecture content to ensure that they were aligned in terms of teaching the same course material. Faculty members would also devote time to creating problems for homework assignments and exams, as well as logistics around administering and grading these assignments. There was also dialogue around course improvement and potential course changes; at the end of the semester, faculty members would reflect on what concepts they may or may not cover in future semesters. Overall, faculty members were concerned with alignment around individual course organization so that students can have a similar and somewhat standardized experience across course sections. Discussion around course logistics also emerged for the treated teams as conversations about their project progress were also integrated along with discussions around the faculty members' courses, as the implementation of project activities is reflected through instructional videos watched by the students, feedback surveys, and homework assignments aimed at testing their hypotheses. This focus on course logistics was consistent with the description from department members of the course coordination meetings pre-implementation.

Student Outcomes and Engagement

Faculty members in the non-treated teams discussed student outcomes, primarily focused on attendance, engagement, and class performance, such as students attending class, students participating in the lecture, and students performing well on major class assignments. Again, this reflects the description of the course coordination meetings from department members pre-implementation.

The treated teams also discussed student outcomes, but were focused on different topics. Many of the treated teams' pedagogical innovation projects were centered around impacting student outcomes (e.g., improving comprehension, understanding, and application of the course material) and overall engagement with the curriculum. Team members frequently deliberated over whether the content of the course was meaningful, whether assignments were relevant and applicable for the students, and how student engagement was evolving as the project progressed.

Relevant Themes for Treated Teams

These specific themes emerged only in the treated teams. The themes were generally related to the teams' teaching innovation projects.

Teaching Innovation Project: Logistics

A common theme emerging from the treated teams is discussion around the logistics and status of their teaching innovation project. Typically, faculty members discussed the progression of the project, individual responsibilities of team members, and implementation of project activities.

Teaching Innovation Project: Application to Industry

Team members within these project teams also discussed the project's relevance to industry. Consistent with departmental goals, one of the goals of the grant is to ensure that MEEN undergraduate students are effectively prepared for engineering industry careers. This theme is apparent in treated team members' discussion around the construction of homework

problems and exam questions. These assignments were developed with the intention to prepare students to be innovative when solving potential applied engineering problems that they may encounter in an industry setting. Other project activities, such as instructional videos, also aimed to develop necessary skills relevant to industry, such as communication, collaboration, problem-solving, and working with/leading diverse teams.

Teaching Innovation Project: Purpose of the Project

As the teams progressed in their projects, team members would frequently reflect on whether they were staying aligned with the main objective of the project. Within these discussions, teams would often refer to content and lessons from the summer workshop series to confirm that they are accurately measuring their progress and ensuring that their project serves the diverse needs of their students. Overall, these teams seemed to be more intentional with their work in that their actions needed to serve the overall project purpose and there would often be much dialogue between the team members to ensure that they are taking the appropriate actions.

Team members would also reflect on how to incorporate more innovative practices into their teaching. Team members discussed goal-setting around innovation and overall improvement of their teaching methods, demonstrating a commitment to continuous improvement as they monitored the progress of their project. Members consistently reflected on their teaching practices and evaluated their impact so that they could make real-time, immediate changes for improved effectiveness.

Teaching Innovation Project: Project Reflection

As teams were reaching the end of their cohort year, members would engage in thoughtful discussion and reflection around the conclusion of their project. Within these discussions, team members would share what they learned from their participation in the project. Team members reflected on their expectations versus actual outcomes (e.g., amount of work needed for the project), the guidance and advice learned from the overall NSF grant, student reactions to their project activities, and next steps as they continue to incorporate these innovative practices into their future classes.

Teams also discussed what advice they would give to the next cohort of teams engaging in a teaching innovation project. Team members provided input on how they would have structured the summer workshop series differently, what indicators are useful in terms of measuring effectiveness and success, and whether project outcomes need to be so strictly quantified. Through these discussions, the mindset shift regarding teaching and teaching innovation is emergent as the faculty members were thinking more intentionally about their teaching, reflecting on their hypotheses and methods of testing them, and contributing to fostering a culture within the department in which they share their learnings with fellow faculty and participate in collaborative learning strategies. Many of the faculty members also utilized their project work as an opportunity to engage in pedagogical research and developed papers to submit to engineering education conferences.

Team Member Obstacles

Faculty members were also transparent in discussing obstacles they encountered as the project progressed. Team members discussed their frustrations with the project, particularly

around time commitments, the amount of work involved, the project timeline, and perceived team efficacy regarding whether the team was meeting their specific objectives. At times, they also expressed their dissatisfaction with student progress and felt that students were not engaging in the project activities or comprehending the material holistically.

7. General Discussion

Our examination of the multiple sources of data collected over the multi-year grant provides evidence that culture change did happen within the MEEN department. The efforts of the grant team have made a noticeable impact in shifting the department's teaching culture to one that supports and encourages iterative experimentation within teaching. The impact of the innovation training summer workshops was quickly seen, as comparison of the pre- and post-training proposals showed improvement in the teams' ability to articulate measurable student outcomes, set incremental goals, align activities with goals, and track their progress. Greater improvement was seen in the second cohort, probably due to changes in the summer workshop structure after the grant team implemented feedback about the summer program from the first cohort. The observational data also indicated that treated teams were much more intentional in their discussions around teaching innovation and incorporated learnings from the summer workshop series and educational retreats to enhance their projects, utilize more innovative teaching methods, and think more critically about pedagogy and teaching improvements. Treated faculty members placed increased value on teaching innovation and intentional pedagogy, which informed their teaching behaviors and methods. Treated faculty members' underlying assumptions also changed as they no longer viewed pedagogical change as extensive and overwhelming, but instead as an accumulation of incremental and manageable changes.

Because of the small sample size, the survey data did not allow us to test change over time, but positive trends within many culture-related areas were observed in these data. A main limitation of the survey data was an inability to gather enough respondents to consistently complete the survey for reasonable comparisons. When implementing longitudinal surveys, other engineering researchers should consider how often they wish to distribute the surveys and be intentional as to when they distribute the surveys (e.g., distributing the surveys at times when faculty members may be less busy).

Ultimately, the pre-and post-implementation interview data provided evidence to culture change within the department. The comparison between the pre-implementation and post-implementation interviews demonstrates that there is increased involvement in positive and productive discussions around teaching among faculty members, a Teaching Community of Practice has emerged from the faculty and become ingrained within the departmental culture, the department is providing more resources to support teaching, leadership is much more encouraging of teaching innovation, and faculty members approach teaching innovation with more confidence and enthusiasm. The interview data highlights a significant benefit in utilizing qualitative methods, as they can provide rich, detailed, and informed insights about the impact of culture change practices and faculty members' perceptions about the culture change process. For future work, engineering education researchers should take a further step in evaluating how these institutional change efforts impact student outcomes and perceptions. While individual teaching innovation projects did measure impact on student outcomes, the broader grant did not evaluate that impact as extensively. Future researchers could possibly utilize methods such as classroom observations or focus groups with students to better understand if these broader departmental

changes cascade down to positively impact student learning and engagement. Overall, the data gathered over the course of the grant demonstrate positive support for engaging in faculty development approaches that prioritize reflective teaching, aim to change faculty conceptions and beliefs and create meaningful and sustainable change in academic engineering departments.

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Appendix

Interview Protocol for Pre-Implementation Interviews

1. Please tell us a little about yourself. For example, how long have you been in the department? What is your research about? What do you teach regularly?
2. As we've mentioned, the TCORPS grant focuses primarily on teaching and teaching innovation. How do you feel about teaching? What do you like? Dislike?
3. What would you say is the main teaching mission of the department?
    a. Rephrase: By teaching mission, we mean "what are the major goals for teaching in the department? And to who is the department answering when thinking about the teaching mission?"
4. How would you describe the culture around teaching and teaching innovation in the department?
    a. What are the competing priorities with teaching—in the department and for you as an individual?
    b. How does the department reward and support teaching? The other priorities?
5. What are the **strengths** of the department for teaching?
    a. Strengths for you?
    b. What are the strengths of the department for improving and innovating teaching?
    c. Strengths for you?
    d. Strengths of your colleagues?
6. What are the **weaknesses** of the department for teaching?
    a. Weaknesses for you?
    b. What are the weaknesses of the department for improving and innovating teaching?
    c. Weaknesses for you?
    d. Weaknesses of your colleagues?
7. What are the **opportunities** in the department for teaching?
    a. Opportunities for you?
    b. What are the opportunities in the department for improving and innovating teaching?
    c. Opportunities for you?
    d. Opportunities for your colleagues?
8. What are the **barriers** in the department for teaching?
    a. Barriers for you?
    b. What are the barriers in the department for improving and innovating teaching?
    c. Barriers for you?
    d. Barriers for your colleagues?
9. What innovations have you tried in your courses in the last three years (if any)?
10. Is there anything about teaching or teaching innovation that I didn't ask about and should have? What else should I know?

Interview Protocol for Post-Implementation Interviews

1. Please tell us a little about yourself. For example, how long have you been in the department? What is your research about? What do you teach regularly?
2. As we've mentioned, the TCORPS grant focuses primarily on teaching and teaching innovation. How do you feel about teaching? What do you like? Dislike?
    a. **New follow-up question: How has the TCORPS grant impacted your feelings about teaching?**
3. What would you say is the main teaching mission of the department?
    a. Rephrase: By teaching mission, we mean "what are the major goals for teaching in the department? And to who is the department answering when thinking about the teaching mission?"
    b. **New follow-up questions**
        i. **Do you think the main teaching mission of the department has changed after the efforts of the TCORPS grant?**
        ii. **How have the major goals for teaching in the department changed?**
4. How would you describe the culture around teaching and teaching innovation in the department?
    c. What are the competing priorities with teaching—in the department and for you as an individual?
    d. How does the department reward and support teaching? The other priorities?
    e. **New follow-up questions:**
        i. **How has the culture around teaching and teaching innovation changed within the department?**
        ii. **Do you feel more prepared to balance teaching innovation efforts along with your other competing priorities after the efforts of the TCORPS grant?**
        iii. **Has the TCORPS grant impacted your perceptions around how the department rewards and supports teaching?**
5. What are the **strengths** of the department for teaching?
    f. Strengths for you?
    g. What are the strengths of the department for improving and innovating teaching?
    h. Strengths for you?
    i. Strengths of your colleagues?
6. What are the **weaknesses** of the department for teaching?
    j. Weaknesses for you?
    k. What are the weaknesses of the department for improving and innovating teaching?
    l. Weaknesses for you?
    m. Weaknesses of your colleagues?
7. What are the **opportunities** in the department for teaching?
    n. Opportunities for you?
    o. What are the opportunities in the department for improving and innovating teaching?
    p. Opportunities for you?
    q. Opportunities for your colleagues?
8. What are the **barriers** in the department for teaching?
    r. Barriers for you?

s. What are the barriers in the department for improving and innovating teaching?
t. Barriers for you?
u. Barriers for your colleagues?

9. What innovations have you tried in your courses in the last three years (if any)?
10. Is there anything about teaching or teaching innovation that I didn't ask about and should have? What else should I know?

Additional Interview Questions

1. Has the TCORPS grant impacted the way you approach teaching and teaching innovation?
   a. If yes, how? If not, why not?
2. Have you tried any innovations in your courses since the start of the TCORPS grant?
   a. If yes, what were they? If no, what is a typical class session like in your course?
3. What changes around teaching/teaching innovation have you seen in the department since the start of the TCORPS grant?
   a. Do you think these changes will be maintained within the department?
   b. Do you think these changes are supported by the majority of faculty members?
4. Do you think you will continue to implement teaching innovations after the conclusion of the grant?
5. Do you see teaching innovation as an easier process now? Why or why not?