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Innovation Training and Its Impact on Faculty Approach to Curricular and Pedagogical Changes

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Evidence Based Practice: Innovation training and its impact on faculty approach to curricular or pedagogical changes

Introduction

The Project called Teams for Creating Opportunities for Revolutionizing the Preparation of Students (TCORPS), is an adaptation of the "Additive innovation" model developed by Arizona State University in their RED (Revolutionalizing Engineering Departments) project [1] and is funded by a National Science Foundation (NSF) IUSE/PFE: Revolutionizing Engineering and Computer Science Departments (IUSE/PFE: RED) grant.

There is widespread consensus that the engineering curricula need to evolve to meet the exponentially fast changes that are occurring to industry needs. The American Society of Mechanical Engineers Vision 2030 [2] articulates the needs and challenges well. However, there is also clear evidence that many of the standard approaches to implementing these changes do not actually achieve the desired results, as documented by the analytical review of literature conducted by Henderson et al [3]. This review focused on different types of interventions from the point of view of the intervening teams. The faculty view of these interventions, based on detailed anthropological observations by Smith and Herckis [4], also point to the complexity of these efforts to change teaching methodologies. There is considerable research [5-8] that has also shown that curricular and pedagogical changes cannot be driven from a "top-down perspective" based on "best practices" but must be driven by faculty who see the need for change and act upon it in a collaborative manner sharing their experiences with each other. As noted by Silverthorn et al [9], based on their experiences with changing the way faculty teach through a National Science foundation ITIP (Integrative Themes in Physiology) project, the following lessons could be drawn:

Lesson 1: Many faculty are interested in improving their teaching

Lesson 2: Lack of instructor time was a formidable obstacle to translating interest to action

Lesson 3: Providing readily usable course materials did not facilitate instructional reform because the materials did not integrate easily into the existing courses

Lesson 4: Departmental and institutional obstacles played a significant role in the failure of the site test phase of the ITIP project

Lesson 5: Technological limitations and the cost of supplies can be obstacles to instructional innovation

Lesson 6: Ethical requirements for conducting the ITIP project were complex and the project would have benefited from communication with the IRBs (institutional review board) of faculty participants' home institutions

Lesson 7: ITIP faculty would have benefited from education on project assessment methods and from being made partners in designing the ITIP assessment protocol

A preliminary interview of faculty in the mechanical engineering department, conducted by the RED team researchers, reinforced lesson 4 and indicated that faculty did not feel that their curricular/pedagogical efforts were recognized, nor did they feel a sense of community where they could share ideas for innovation. Furthermore, reinforcing lesson 2, there was a general consensus that they lacked the time to carry out the changes that they had in mind.

A study of the lessons provided suggests the hypothesis that faculty are interested in improvements and indeed know what improvements are needed, but they lack a systematic innovation cycle approach, a way to evaluate the scope of their projects, and means for assessing the outcomes and then modify their innovations appropriately.

Based on this, the TAMU RED project is focused entirely on culture change via faculty development and partnership, eschewing prescriptive notions of curricular change entirely. The aim is to create a culture that is faculty driven, encourages a sustained process of incremental improvement and responsiveness to student learning through experimentation, measurement, and sharing. Two key levers in this culture change are (a) a faculty development series focused on innovation and data-driven change, and (b) the creation of faculty driven communities of practice or "soft wired" teams that support each other and sustain incremental change across semesters as faculty cycle in and out of courses. Ultimately, the goal of this project is to enhance a departmental culture in Mechanical Engineering where faculty regularly discuss current curricular effectiveness and are empowered to develop pedagogical innovations that enable all students and faculty to thrive.

For the first objective, our aim is to help faculty reduce effort and risk in implementing pedagogical changes. Faculty already have investigative and experimentation-driven processes in place for research and a keen understanding of data to support their hypotheses. We aim to leverage this preexisting strength and knowledge by extending it to the faculty-led, small-scale, iterative improvement of curriculum and pedagogy. Based on the faculty interviews, our hypothesis is that faculty don't lack teaching innovation ideas, however, they have difficulty in framing their innovation ideas to the regular incremental pedagogical changes and connecting them to measurable and explicitly articulated student outcomes in terms of curriculum, pedagogy or inclusiveness. Furthermore, they have difficulty in evaluating the scope of their ideas; too often the task that is undertaken is too large and there is no time to evaluate their efficacy or share their findings.

In order to address faculty concerns regarding the time necessary for curricular change, a formal process for ***incremental innovation*** was introduced to our faculty based on the idea of a build-measure-learn-share-modify (B-T-L-S-M) Cycle. The highlight of this model is to help faculty organize themselves into communities of practice [10, 11] that are (1) inspired by shared artifacts/ideas, (2) openly share and learn about the technology and process used to create these

artifacts/ideas, (3) design and prototype their own modified version of the shared artifact/idea, and (4) share their modified artifact/idea back with the community [10]. To encourage faculty to innovate at an incremental scale, each teaching experimentation is expected to go through this B-M-L-S-M cycle with an expectation that pedagogical changes will be continuous, and based on the notion of a minimum viable product or Experiment (MVP) [12, 13]: start with a set of assumptions; determine what to learn first by identifying the riskiest, or "leap of faith", assumptions; then determine what to measure to prove or disprove the "leap of faith" assumptions; and finally design an MVP to test their assumptions. The concept of MVP helps faculty to pare down the scope of their innovation and start this circle as quickly as possible at minimal costs and resources.

Unlike typical Engineering Workshops at Texas A&M university that are focused on introducing faculty to best practices, the faculty curricular innovation workshop was based on the lean startup style "build-measure-learn" cycles [12, 14] but tailored for curricular innovation. This summer innovation workshop can itself be considered as an “incremental innovation” and seek to answer a key question: "*whether and to what extent the innovation training workshop series can help faculty with framing/planning their curricular or pedagogical changes"*. We then seek to use the evidence gathered to re-examine our assumptions and to suitably modify our workshop. This Evidence-Based Practice seeks to provide our preliminary insight into this question.

Methods

1. Initiation of Educational innovation teams

TCORPS recruited its first cohort of instructors in March 2021 and the second cohort in April 2022 for participation in the summer 2021 and summer 2022 faculty development workshop respectively. The first cohort consisted of 14 faculty with the proefile shown in tablee 1

cohort #	Total faculty	Faculty Type		Years of service			Exeprience with Engg Edu. Research		
		TT	APT	<5	>5, <10	>10	None	Some	experienced
1	13	3	10	5	5	3	7	3	3
2	13	8	5	4	5	4	10	1	2

Table 1: profile of participating faculty in each cohort. (TT= Tenured or tenure track, APT= Associated Professional Track (Non-tenured) faculty)

To help initiate the culture change, faculty at the first were invited to form teams to propose small changes that they would like to implement into existing course curricula. The teams were asked to submit (a) the title of their innovation, (b) the course(s) involved, (c) the participants in the community of practice, (d) the teaching innovation that was being proposed, (e) the current practice that they are seeking to change, (f) if their innovation was focused on any historically underrepresented demographic group, and (g) whether they were willing to participate in the

summer workshop series. In 2021 cohort, a total of 10 project teams (with approximately 15 faculty out of a total of about 70 faculty) submitted proposals; these 10 teams had considerable overlap across their membership. Finally, four teams were selected as the pioneers of educational reform. They were chosen to ensure that the maximum number of faculty participated while keeping the group to manageable sizes. Their proposals are: (1) Conceptual Rapid Fire Ice Breakers (related to manufacturing); (2) Real World Material Science; (3) Music of the Machines (related to our instrumentation course); (4) Professional Development (related to teaming and, unlike the other teams, would affect multiple courses), and all the faculty are willing to participate in the summer workshop series [15]. Proposals were selected based on what classes they were teaching and whether there was overlap and the logistics of managing the course assignments, *but not on any measure of the likely success of their innovation)*. This was a deliberate choice since we wanted to ensure that the RED team were not the judges of their innovations but only facilitators to help them evaluate their own success and make suitable modifications.

In the 2022 cohort, 16 teaching innovation proposals were submitted, and 5 proposals were selected. 5 project teams were finally formed including 14 faculty, and 6 undergraduate courses are involved in their pedagogical innovation. The initially proposed proposals are: (1) Enhancing design experience and problem-solving skill in the Solid Mechanics in Mechanical Design Curriculum with SolidWorks Simulation; (2) Facilitate student learning through Blooms Taxonomy-based assignments; (3) Investigating mind-mapping as a tool for improving problem solving in engineering mechanics; (4) Extended Reality Enhancements to the Thermal Sciences Curriculum; and (5) Hands-on, minds-on, and game-based learning for Solid Mechanics Curriculum. Cohort 1 was primarily composed of Academic Professional Track (APT) Faculty whose primary role in the department was teaching. Of these, a majority of proposals were in the mechanics and materials areas but not many in the thermal sciences and dynamics and controls areas. A conscious effort was made in year 2 to recruit faculty in these areas; thus cohort 2 consisted of about 7-8 Tenure track faculty in areas related to thermal sciences and mechanics. They were paired with APT faculty so that there was a mix of different faculty in each team.

1.1 The rubric

As can be seen from the list of projects, faculty had many creative ideas to improve their curriculum and pedagogy. However, the RED team sought to help them with a systematic process for evaluation of their own innovation so that they gained the knowledge to self-evaluate their progress and make changes to it. In order to help them with the process, the RED team developed a systematic rubric to assess how well they articulated their change proposal based on a rubric that consists of 5 elaborated scales towards 7 different aspects [see Appendix A]:

1. Is the goal was student outcome oriented or is it something that they wanted to do?
2. How aligned was their proposed activity to their stated goals?

3. Whether they have leading indicators (i.e., progress indicators indicating how well they were implementing their proposed activities) and lag measures (ways to evaluate whether they have met their goals)?
4. Whether they have articulated any plan for tracking their lead and lag measures and making plans for modifications?
5. How do they address inclusivity in their plan?
6. Did they articulate the state change in the form of "From X to Y by When" so that the start and the end were clearly and measurably articulated?
7. Are they taking an incremented/iterative approach, or is it a big upheaval?

The scoring rules remain unchanged and have been used for two years. The teaching project teams for 2021 and 2022 were evaluated separately based on their teaching innovation proposals. In 2021-2022 academic year, 4 RED team members scored each proposal (pre and post) based on the rubric, and in 2022-2023 academic year, 5 RED team members independently assessed the proposals (pre and post) based on the same rubric. The overall score of each item is calculated by the average score of each item (average of all teams and evaluators). An inter-rater reliablity test was run on the ratig

1.2 Results from the Pre-training project submissions

As can be seen in Figure 1, it is clear that faculty in both cohort 1 and 2 struggled with all aspects of the innovation process - especially in articulating measurable student outcomes rather than just their "leaps of faith" on what effect it might have. For example, if the aim is to "show a video", but one does not commit to evaluate its hypothesized effect, it will always be "successful". A striking aspect of the results is that almost no faculty considered inclusivity (item 5) as an important aspect of what they were proposing even when prompted to do so. In some cases, the faculty chose to make major changes to the course content without realizing that they would not have the time to do so.

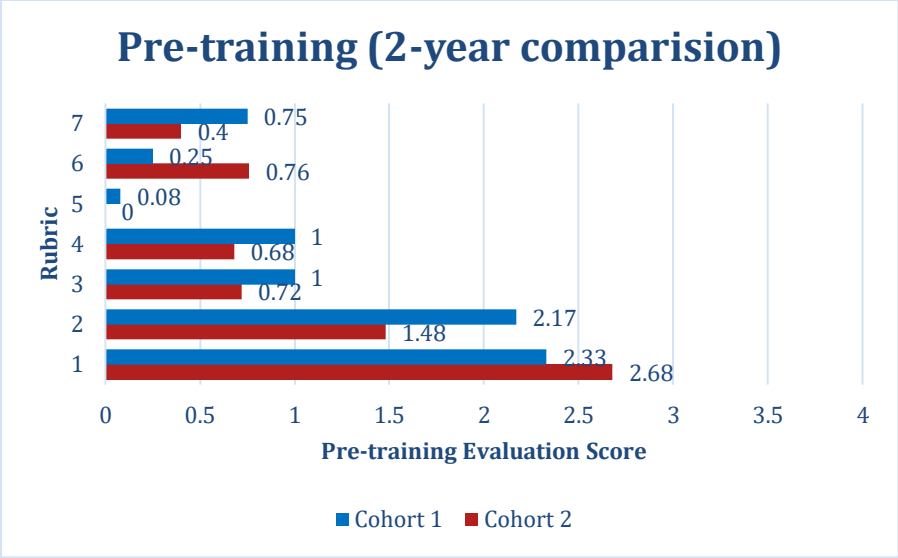


Figure 1: Scores on the rubric before the workshop in Cohort 1 (2021) and Cohort 2 (2022)

The pre workshop results based on the rubric clearly points to the challenges that are encountered in any educational change --- faculty (whether they were APT or tenure track or tenured), even if they are dedicated to teaching, were novices in educational innovation and were rather unclear about the formative aspects of their role in meeting student outcomes other than conveying the information in the course and doing standard summative quizzes and exams at the end. The results of the pre training rubric became the motivation for the workshop organization.

2. Framework to Encourage Innovation

2.1 Faculty development workshop

The workshop was focused on introducing faculty to the basics of student outcome measurement, student diversity, and student learning; and, on the other hand, on the discussion of incremental innovation, goal setting, and educational (curricular and pedagogical changes) change management. The faculty development workshop series spanned the entire summer. It was composed of six 2-hour online workshop classes (see Tables 1 and 2 below), a (mostly) self-paced innovation mindset course, and four optional informal working sessions. Before the innovation training sessions, faculty are encouraged to take the online Innovator Mindset™ course [16] including an assessment to help them assess their thinking mode and get familiar with the related concepts [15].

2.2 AGGIES process

In order to provide a framework for faculty to keep track of the progress of their innovation and its goals, the RED team modified The 4 Disciplines of Execution [17] for our education project into the "AGGIES" process. The AGGIES process is introduced to every team to help their goal

setting. The acronym was chosen based as follows: 'AGG' is the Absolute Greatest Goal, 'I' is indicators, 'E' represents the expectations and accountability, and 'S' is the scoreboard for keeping track of progress. The teams were coached to focus on taking action to improve the leading indicators (to predict and influence the results), rather than the lagging measures (results) themselves. As examples, leading indicators could include student attendance, student engagement in optional practice sessions, and student errors on practice questions (both number and type) whereas lagging indicators could include student grades, student end-of-semester or senior design project content, or students making connections between curricular components across courses. In the workshop, each team brainstormed their student-outcome-oriented AGG in the form of "from X to Y by when"; where X and Y represents the improvement in their lagging measure over time. For example, a good AGG might be "from 50% of students to 75% of students connecting material from Course 1 to Course 2 by the end of one year." Next, the teams determined the leading indicators expected to influence their AGGs. The faculty participants then designed a scoreboard to track both their lagging measures and leading indicators. Finally, the teams scheduled their regular AGG meeting where the teams would meet to (1) report out on preceding AGG meeting commitments, (2) review updates to the scoreboard, and (3) commit to actions aimed at improving the leading indicators, thereby setting the expectations of what each team member should accomplish prior to the next AGG meeting.

Assessment and Results on the Evolution of Faculty Mindset

1. Academic 2021-2022 cohort

The innovation workshop topics that were selected in the first year are shown in table 2. The 1st cohort workshop items 2 and 3 were carried out by Drs Watson and Bergman (both with considerable knowledge of literature in educational psychology). Items 4, 5 and 6 (the AGGIES process) was custom built by two members of the RED teams (Drs. Cynthia Hipwell and Dr. Chris Seets with experience in innovation from Seagate Technology) for education from the Innovator Mindset™ and iterative innovation approach. After the workshop, faculty can take the innovator assessment again.

Table 2: 2021 Summer Workshop Series

Session	1st cohort workshop topic
1	Kick-off
2	Pedagogy and assessment sharing toolkits
3	Psychology and teaching, learning, and thinking: What is the current research on how students think
4	Goal setting (AGGIES process; see below)

5	Innovator mindset training
6	Iterative learning training

The results from the faculty resubmission of their proposal after the 1st cohort workshop in the fall of 2021 are shown in figure2. As can be seen, there were increases in their ability to plan their changes (especially on items 5, 6, and 7) related to plans for inclusion, measurement and incremental learning. However, on an absolute scale, their ability to plan changes were still substantially low.

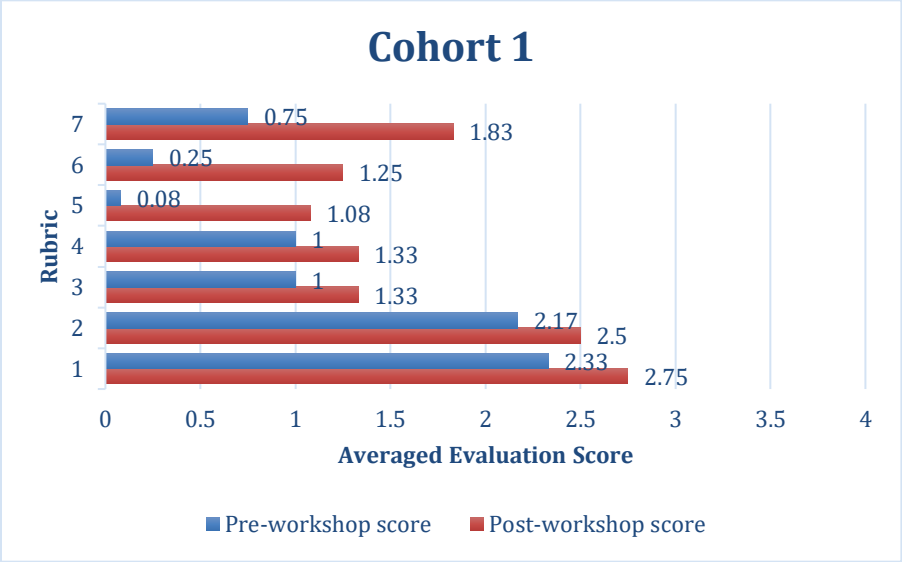


Figure 2: Comparison between pre workshop and post workshop scores based on the rubric in Appendix A

The faculty were debriefed after one year intervention by asking them "what did they wish that had known now that they have gone through 1 year of innovation cycle". The faculty unanimously identified the need for (a) early training on the innovation (AGGIES process) and (b) specific, engineering focused and detailed information on how to measure the effect of pedagogical interventions on student outcomes.

2. Academic 2022-2023 cohort

Based on the data in Figure 2 and 1st cohort faculty debriefing, the workshop structure was changed in year 2, to focus more pointedly on (1) the Aggies process and (2) on how to measure educational outcomes. We requested Dr. Saira Anwar (expert on measurement of pedagogical interventions in engineering) to help faculty on how to write learning outcomes based on the idea of **SMART—Specific Measurable Attainable Relevant Timebound learning outcomes** (see Table 2, session 3). This provided faculty a rubric to evaluate their own learning outcome proposals and led to lively and deep discussions on what exactly they were trying to achieve -

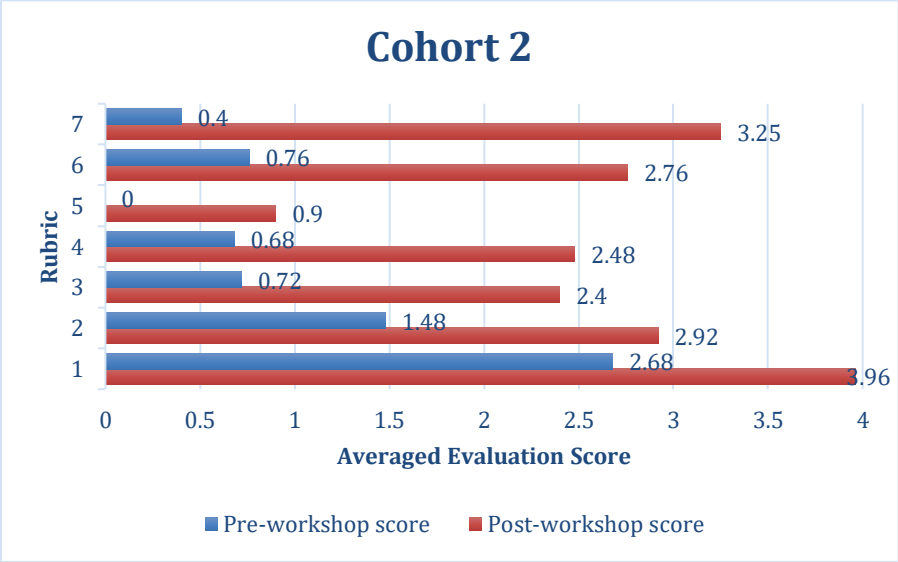
what is their Absolute Greatest Goal, and what are leading and lagging indicators of their progress towards achievement of these goals.

Table 2: 2022 Summer Workshop Series

Session	2ed cohort workshop topic
1	Innovation process execution, AGG working session, Iterative learning
2	Psychology and teaching, learning, and thinking
3	Direct and Indirect Ways to Measure Educational Outcomes
4	Teaching innovation teams present AGGIES summary
5	Inclusive and Engaging Learning Environments
6	Team Presentations: AGGIES + 1st MVP

The results from the 2nd cohort are shown in Figure 3 and demonstrate that there was significant improvement in the ability for faculty to articulate a student learning outcome based change and the leading and lagging indicators. Workshop 2 showed that there were substantial improvements in their ability to plan for measurable outcomes, leading and lagging indicators and identifying the scope of their project (and thus revise their Minimum Viable Experiment) based on what they plan to measure.

Figure 3: Comparison between pre training and post training rubric scores for cohort 2



This indicates that the 2nd workshop had significantly more impact on the faculties ability to ***self-regulate*** their own pedagogical changes. From a comparison of the wording of the pre and post

workshop proposals, it is found that: first, faculty moved from "completion of task" centric statements before the workshop to "student outcome oriented" statements after the workshop; further, teams articulated their goals following the workshop in the form of an AGG (from X to Y by when), even though the content of the proposed activities did not change much. However, the teams still did not articulate their plans related to inclusivity in their proposals.

3. Results on post-training scores and improvement for both cohorts

Figure 4: Post training comparison between the two cohorts after the workshop

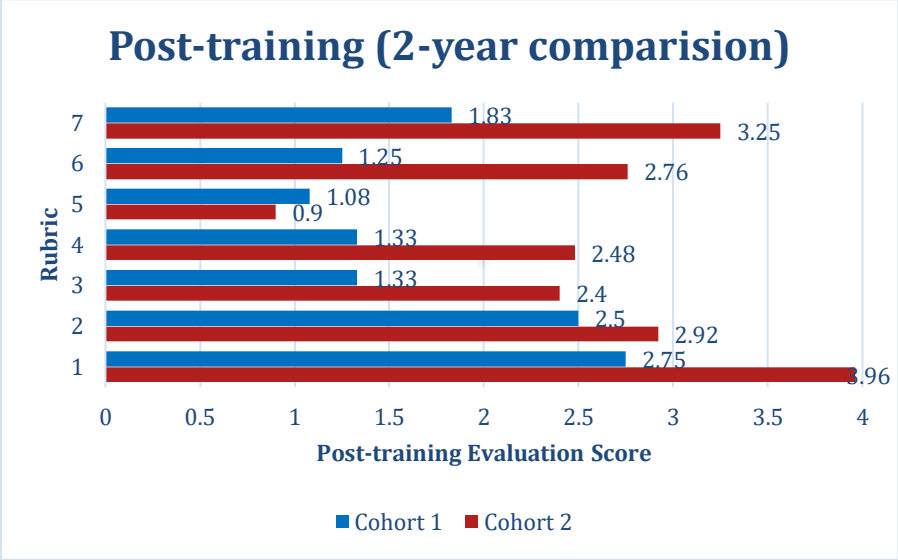


Table 3: Post-training evaluation scores for cohort 2021 & cohort 2022

	Rubric No.1	Rubric No.2	Rubric No.3	Rubric No.4	Rubric No.5	Rubric No.6	Rubric No.7
Cohort 1 Post-score	2.75	2.5	1.33	1.33	1.08	1.25	1.83
Cohort 2 Post-score	3.96	2.92	2.4	2.48	0.9	2.76	3.25
Improvement (by year)	+1.21	+0.42	+1.07	+1.15	-0.18	+1.51	+1.42

From Figure 4 and Table 3, the data suggests that the modified workshop was significantly better in helping improve the faculties planning abilities in almost every case.

Table 4: Cohort 2021 & cohort 2022 improvement (Post-Pre) in planning after the training

	Rubric No.1	Rubric No.2	Rubric No.3	Rubric No.4	Rubric No.5	Rubric No.6	Rubric No.7
Cohort 1 Improvement	+0.42	+0.33	+0.33	+0.33	+1	+1	+1.08

Cohort 2 Improvement	+1.28	+1.44	+1.68	+1.8	+0.9	+2	+2.85

Table 4 summarizes the improvements in the planning measures for the 2 cohorts, The comparison between the original (pre-training) and revised (post-training) project description reveals a number of changes in how faculty approach their teaching innovation projects. From the data level, after the workshop, almost all the teams improved their scores. They consciously utilized an iterative innovation model and improved their proposals. Third, the team's scores improved the most in items 5, 6 and 7 above. In the case of the same activity plan, each team could now formulate goals and plans in stages, and consider continuous updates based on phased learning and feedback. AThe Interclass Correlation Coefficient (ICC(1,k)) (based on Two way random effects for consistency with mutliple raters) was computed for the ratings and the ICC scores ranged from 0.52 (for the post rating of the second cohort with 5 raters) to about 0.85 (for the pre rating of the 1st cohort. This indicates that the ratings were moderately reliable with the post rating of the second cohort indicating larger disagreements between the 5 raters.

Creation of a Teaching Community of Practice

Following the summer workshop series, it became clear that the teams wanted more opportunity for feedback and support from the workshop leaders (who are also the PIs of the grant) and the other teams. Thus, the teaching innovation members meet with the workshop instructors over the academic year on a monthly basis either virtually or in person to update their progress, share learning on their MVPs and discuss options for future work. The Department Head received feedback that this meeting had been viewed very positively and that more faculty wanted to attend. This working group meeting gradually evolved into the "Mechanical Engineering Teaching Community of Practice", making it a bottom-to-up structured, orderly expanded, continuous learning and sharable community. Interested graduate students and all faculty are invited to participate and provide their feedback and suggestions. This is very much in alignment with the RED team goal of leaving the department with a sustainable continuous improvement process and community of practice beyond the grant.

Conclusions and Future Work

In this paper, we considered an evidence-based practice approach to innovation training workshop to facilitate faculty self-regulation of pedagogical changes. The AGGIES process helped faculty consciously follow an iterative innovation methodology to formulate their teaching plans in a manner that was conducive to self-regulation. Every team has a common sense of iterative teaching innovation, which indicates the contribution of the incremental innovation training as a means for improving faculty approach to curricular or pedagogical changes and percolating faculty teaching culture change.

The proposed rubric to evaluate faculty educational change proposals also helped target the training workshop to the needs of the faculty. In particular, faculty had considerable difficulty in planning and articulating ***measurable*** student outcome changes as well as identifying and monitoring indicators and scoreboard to evaluate their own progress. The results from the workshop show that the AGGIES process together with specific training on measurable student outcomes is a key step towards a more reflective sharing and self-regulating teaching community of practice.

During these two years (academic year 2021-2023), we have been tracking how well the different teams are applying the iterative innovation methodology taught in the workshop during the implementation process on the "Mechanical Engineering Teaching Community of Practice". We are planning to release surveys at the end of April, 2023 to further measure faculty's teaching innovation outcome, evaluate the impact of innovation training workshop from the perspective of faculty, and to evaluate the departmental teaching culture change. We will summarize this part of the work in our next paper.

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Appendix A: Rubric for evaluating faculty ability to follow the AGGIES innovation process

In 2021-2022 academic year, 4 RED members scored each team's proposals (pre and post) based on the rubric. To evaluate the overall performance of the 2021 cohort, towards each rubric question, it is firstly averaged the scores of each evaluator on the 4 teams, and then it is averaged these 4 evaluators' scores, thus obtaining the score of the first cohort under each rubric.

In 2022-2023 academic year, 5 RED members independently assessed the proposals (pre and post) based on the same rubric. The scores of each evaluator were averaged on the 5 teams. Then , 3 outliers that were significantly different (by more than 2 points) from the rest of the evaluators, and then averaged the remaining scores to obtain the scores of the second cohort.

Table 5: Systematic rubric to evaluate teaching innovation proposals

RUBRIC				
1: Decide whether their goal was student outcome oriented?				
0	1	2	3	4
No goal indication	Some goals	Student mentioned	Student outcome mention	Student outcome is measurable
2: Whether their activity is aligned to their stated goals and leading measures?				
0	1	2	3	4
Activities not aligned with the stated goals and leading measures	Targeted just at the goal	Targeted just at the goal and somewhat toward leading measures	Activity targeted at improving leading measures	Activity targeted at improving leading measures and modified based on continuous learning
3: Whether they have leading indicators and lag measures for tracking their progress?				

0	1	2	3	4
No measures indication for tracing	Measurement but not clear lead or lag	Lag measurement	Lead and lag measurements	Quantifiable assessment method (reflect the degree of progress)
4: Whether they have articulated any plan for tracking their lead and lag measures and making plans for modifications?				
0	1	2	3	4
No plan for tracking	Tracking the measures has been mentioned	Tracking the lag measures	Tracking the lead and lag measures	Tracking lead and lag measures and make plans to make modifications at AGG meetings
5: How do they address inclusivity in their plan?				
0	1	2	3	4
No consideration of inclusion	Mentioned but no goal/measurement	Considered (goal included)	Considered and measurable	Considered, measured, and actions/goals to improve
6: Did they articulate the state change like "From X to Y by When"?				
0	1	2	3	4
No goal	No timeline or measurable improvement	Have timeline but no measurable improvement	Have timeline and know what to measure, but need baseline to specify X and Y	Detailed stage change, clear set points and timeline
7: Are they taking an incremented/ iterative approach, or is it a big upheaval?				
0	1	2	3	4
One-time, not an iterative approach	Iterative approach, but only execute and measure once	Iterative during one semester	Iterative during several semesters	Sustainable, iterative approach, sharing with others