Work in Progress: Faculty choice and reflection on teaching strategies to improve engineering self-efficacy

Abstract

This work-in-progress paper seeks to examine faculty choice of teaching strategies to improve students' engineering self-efficacy [1], [2] (belief in one's abilities to successfully accomplish tasks in engineering) as well as their reflections on the effectiveness of the teaching strategy. Increases in self-efficacy have been related to improved academic and career outcomes [3], especially for women in non-traditional fields such as engineering. The goal of the study is to determine simple yet effective strategies that can be implemented in engineering classrooms to improve self-efficacy.

Seven engineering faculty members participated in a faculty learning community (FLC), a semester long program to learn about teaching strategies in each of the four areas of self-efficacy; mastery experiences (e.g., active learning, scaffolding), vicarious learning (e.g., guest lectures, peer mentors, group work), social persuasion (e.g., constructive feedback, positive self-talk), and emotional arousal (e.g., test anxiety, building rapport). The faculty then chose and implemented strategies in each of the four areas in one of their engineering courses. Monthly meetings of the FLC during implementation allowed faculty to share their experiences and suggestions for refinements in their teaching strategy.

The paper examines the faculty member choice (why they chose to use particular strategies in their course) as well as their reflections on how well the strategy worked (impact on student learning vs ease of implementation). In addition, the paper examines in-class observations and student survey responses to determine if they felt a particular strategy was useful. The research seeks to identify strategies that faculty members chose and are viewed as effective by both the faculty and students. The presentation will seek additional feedback from the wider community on the effectiveness of teaching strategies to improve self-efficacy and future work will include the analysis of additional surveys that were administered to measure student self-efficacy with the goal of determining simple and effective strategies that can be implemented in engineering classrooms.

Introduction

Faculty members have a myriad of teaching strategies to choose from when teaching a course. This paper examines the faculty member choice (why they chose to use particular strategies in their course) as well as their reflections on how well the strategy worked (impact on student learning vs ease of implementation). The strategies considered focused on improving student's sense of engineering self-efficacy [1, 2] (belief in one's abilities to successfully accomplish tasks in engineering). The study is comprised of seven engineering faculty members that participated in a faculty learning community (FLC). The faculty members learned about various teaching strategies to improve student self-efficacy, chose a few selected strategies, and implemented them in their courses. In this work-in-progress paper, we seek to examine the questions of: *Why did faculty choose a particular teaching strategy?* and *How effective were the strategies used from the students and faculty's point of view?* The overall goal is to determine simple and

effective strategies that can be implemented in engineering classrooms to enhance students' engineering social cognitions.

Background

Simple yet effective teaching strategies can be implemented in engineering classrooms to improve students' engineering self-efficacy (belief in student's ability to perform in engineering related actions) and outcome expectations. If these social cognitions are impacted via teaching strategies, then a student's performance, persistence, and approach/avoidance behavior in engineering may also be impacted. To understand the basis of the study, the following section reviews the relevant theoretical background on social cognitions.

SCCT (Social Cognitive Career Theory)

Social Cognitive Career Theory (SCCT) explains the development of career related interests, choice goals, and actions and performance (Figure 1). The theory is based on Bandura's [1, 2] social cognitive theory that hypothesizes that the social cognitions affect an individual's engagement and persistence in domain specific behaviors. The key social cognitions in the model are self-efficacy (i.e., confidence in one's ability to successfully perform a domain-specific task) and outcome expectations (i.e., anticipated outcomes of a particular behavior). Self-efficacy has been shown to influence approach or avoidance behaviors, quality of performance, and persistence [4]. It has also been found to be more indicative of success than actual skills at a particular task [5]. Self-efficacy is not a trait (related to a person's skill level) but rather person's cognitive appraisal of their future performance [6]. As such, it is domain specific. Outcome expectations are related to the expected outcomes one has when engaging in tasks in a given domain. If good outcomes are expected, then a person is more likely to engage in the task. The reverse is true for negative outcomes. Bandura [2] hypothesizes that outcome expectations are determined by self-efficacy beliefs, as people will expect positive outcomes for activities that they possess strong self-efficacy.

SCCT assumes the that social cognitions are influenced by four sources of learning experiences (i.e., performance accomplishments, vicarious learning, social persuasion, and emotional arousal) [1,7]. *Performance accomplishments or "mastery of experiences"* refer to the experiences a student has when they are learning a new skill. For example, if they try to solve a problem and get the correct answer, then they increase their confidence that they can continue to do well in solving similar problems. Similarly, the experiences can also work in a negative direction if the student's solution is not correct. These experiences are believed to be the strongest predictors of self-efficacy [8] and for a meta-analysis for SCCT and self-efficacy measuring across that across gender, race and age as moderators [9]. *Vicarious learning* or observational learning is learning that is derived from indirect sources such as hearing or observation, rather than direct, hands-on, experiences. In reference to self-efficacy, it is the observation of people around us, especially people we consider as role models. Seeing people similar to ourselves succeed by their sustained effort raises our beliefs that we too possess the capabilities to master the activities needed for success in that area. However, since observing is not a direct reflection on one's one skill, it is believed to have a weaker influence on self-efficacy beliefs relative to other sources. *Social persuasion* or *verbal persuasion* is being told by others that you can succeed. This often takes the form of positive feedback from instructors, peers, role

models or even one's own positive self-talk. When a person is told that they have what it takes to succeed, they are more likely to achieve success. In this way, self-efficacy becomes a self-fulfilling prophecy [10]. While not as powerful as mastery experiences for strengthening self-efficacy [11], being told by a trusted person that one possesses the capabilities to achieve goals will do more than dwelling on our deficiencies. Finally, *emotional arousal* refers to the emotional and physical reactions and the students' perception of them. People who have a high sense of efficacy are likely to view their state of affective arousal as an energizing facilitator of performance, whereas those who are beset by self- doubts regard their arousal as a debilitator [1]. Helping students manage their anxiety and enhancing their mood improves their overall sense of self-efficacy. Previous studies [12], [13] have linked self-efficacy to predicted academic performance goals and actual academic and work performance.

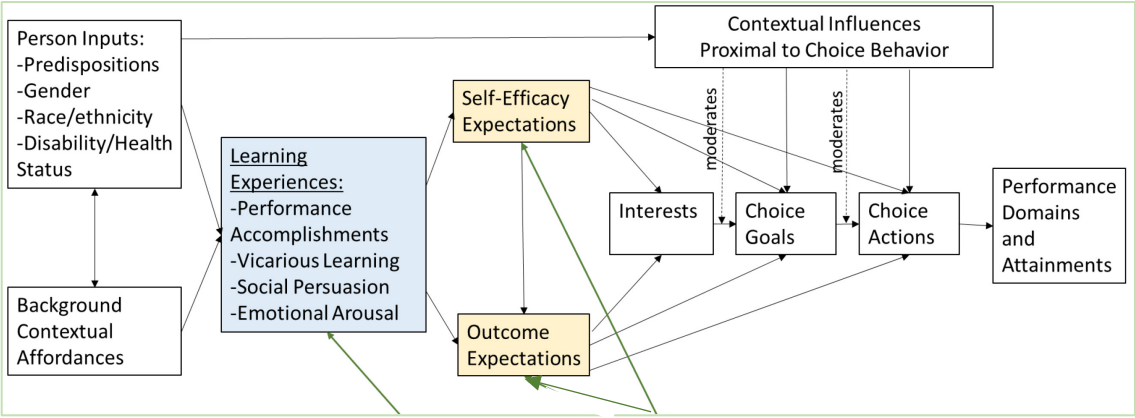

Figure 1: Adapted Figure of Self-Efficacy and SCCT Model [7]

The four sources learning experiences described have been shown to account for significant variance in STEM social cognitions of self-efficacy and outcome expectations according to a recent meta-analysis [8]. In turn, social cognitions shape the student's career interests and goals as well as the student's academic performance and persistence [12], [14]–[16]. Therefore, teaching strategies aimed at improving the learning experiences for students can lead to overall improved performance and persistence in engineering domains.

Teaching Strategies for Social Cognitions

Teaching strategies targeted at each one of the four sources of social cognitions were introduced to the FLC through a semester long program. Faculty learned about the strategies and chose the ones they thought were best suited for their courses. A summary list for each social cognition is presented in Table 1.

Table 1: Teaching Strategies for Social Cognitions

Social Cognition	Strategies	Details
Performance Accomplishments	Motivate students	Relate class objectives to activities and future career goals, help students link class behaviors to performance, help students set course goals

or Mastery Experiences	Active learning	In-class problem solving or discussions; strategies such as think-pair-share, polling, peer teaching, project-based learning
	Hybrid or flipped classroom	Provide reading materials or videos before class, quizzes to gage comprehension; Saves more in-class time for active learning
	Student Preparation	Establish student buy-in, make preparation do-able, make positive results visible, reinforce good habits
	Introduce and Practice	Learning cycle – exploration, introduction, application. Break-up class time with activities
	Structuring Skills	Breaking up complex problems into manageable chunks
	Meta-cognition	Students thinking about how they learn; exam wrapper, critical incident questionnaire, growth mindset
	Course Alignment	Align course goals/outcomes with learning objectives and activities
Vicarious Learning	Guest Lecture	Positive role models (usually career professionals) that can highlight overcoming challenges, how to succeed, and diversity
	Peer Mentors	Fellow students or TAs that can help model successful behaviors; training and effective use
	Group Work	Students working in groups see how others struggle and succeed; group structure and fair assessment methods
	Demonstrating skills	Worked examples with detailed explanations that scaffold problem, demonstration of error paths
Social Persuasion	Constructive feedback	Useful suggestions and comments to help student understand material. Task focused with specific direction, motivating.
	Instructor support	Less teaching plus more feedback through technology, peers, other teachers
	TA support	Training of TAs to provide constructive feedback
	Peer support	Students provide feedback to each other, need structure
	Self-support	Students use rubrics and journals to assess their own work, use of positive self-talk
Emotional Arousal	Test Anxiety	Empowering students, meta-cognition, non-threating classroom environment, review, alignment to learning objectives, smaller stakes exams, humor
	Learning/coping strategies	Recognition of emotions and strategies to help cope
	Rapport	Set positive tone, introduce yourself, create sense of community
	Engaging Experiences	Humor and encouraging words, proactive atmosphere, engaging activities, field trips

Method

Data Collection and Instruments
For this study, we gathered the following data during the Fall 2021 semester:

1) **Faculty member reflections**: Faculty members were asked to choose strategies that impacted each one of the four sources of social cognitions. Each month of the semester, the faculty learning community (FLC) met to discuss their experience and how to improve implementation. Their discussions and summative reflections were documented. The summative reflection was completed at the end of Fall 2021 and included the open-ended questions: 1) Which strategies were implemented? 2) Why did you choose those strategies? and 3) How well did you feel that the strategy worked in the classroom?

2) **Class observations and student surveys**: In the last 3 weeks of Fall 2021, researchers conducted structured in-class observations. An observation protocol guided the process and focused on student-centered strategies and describing how those strategies were used. Moreover, the protocol required observers to provide evidence of students' involvement in the designed class activities. Observers took notes based on the observation protocol to collect standardized data. For each in-class observation, at least two researchers participated in the observation session. Notes from the same class were compared and discussed to collect sufficient details. Figure 2 provides an example of the Verbal Persuasion record section regarding self-efficacy in the observation protocol.

Verbal persuasion/ motivation of students

For each, indicate if this strategy is used, and provide notes if you wish.

	Enter Yes/ no	Notes:
Provides real world examples of how this skill / knowledge is used		
Use of positive reinforcement		
Feedback is constructive		
Other motivational strategies		

Figure 2: **Verbal Persuasion Record Section in Observation Protocol**

At the end of the class observation session, students were invited to complete a short anonymous questionnaire via Qualtrics. Participants' demographic information was not collected. The questionnaire asked participants to 1) rank the effectiveness of the class, and 2) the effectiveness of the particular activity that instructors adopted in helping to learn the course material using a 1-5 scale with 1 = *not effective* and 5 = v*ery effective*. The questions were "How effective was today's class in helping you to learn the course material (SQ1)" and "How effective was the

activity "(strategy name)" in helping you to learn the course material (SQ2)." Regarding the reliability of this two-item scale, we calculated the Spearman-Brown coefficient [17]. These two items were found to be positively correlated, $r(229) = .61$, $p<0.01$. In addition, participants responded to two open-end questions which aimed to explore participants' learning experience. "What was the most important thing you learned today? (Q1)" and "What is the muddiest point still remaining after today's class? (Q2)"

Participants

Participants consisted of students enrolled in seven engineering courses at a public land grant university in the Midwest. Table 3 explains the general information for the seven courses.

Table 3: Course Information and Participants

Course Number	Course Level /Department	Instructional Model	Enroll-ment	In-class survey responses
1	So. -Engr.	In-person	240	114
2	Jr.-Civil	In-person	42	26
3	Jr.- Mech.	In-person	25	10
4	So.-Info. Tech.	Online-Sync	100	23
5	Jr.-Chemical	In-person	39	19
6	Jr.-Industrial	Online-Async	33	not observed
7	Fr.-Chemical	In-person	54	42

Data Analysis

Faculty reflections were reviewed and summarized to explain which strategies faculty members selected, their reflection on how well the strategy worked and reasons for selecting the strategy.

Analysis of the student surveys used coding approaches to identify the themes from students' responses to the questions. The open-ended answers from the student survey were grouped into three categories. For the question "What was the most important thing you learned today", the first category reflects that the students did not know or were not sure what they learned. The second category reflects that the students understood what they learned in class by summarizing or explaining the main knowledge or materials in class. The third category indicated that students wrote incorrect answers about the class contents or misunderstood the class materials. For the question "What is the muddiest point still remaining after today's class?", the first category reflects that the students indicated that nothing was uncertain in the class. The second category reflects that student responses pertained to the topic of the class. The third category indicated that students' responses did not pertain to the specific topic of the class or were general in nature (i.e., lack of knowledge). Coding was conducted by two independent researchers and compared.

The numeric answers from the two item 1-5 scales in students survey were entered and analyzed using the RStudio to calculate the range and mean scores. The Spearman-Brown coefficient was calculated by SPSS Statistic.

Results

Faculty reflections

Results from the faculty member reflections were reviewed and summarized as shown in Table 4. Teaching strategies are categorized by the sources of social cognitions: Performance Accomplishments (PA), Vicarious learning (VL), Social Persuasion (SP), and Emotional Arousal (EA). Some strategies implemented crossed several sources of social cognitions.

Table 4: Faculty member reflections

Course Number	Teaching Strategies	Reflection	Choice
1	Hybrid learning (PA – readings and quizzes prior to class)	Students taking quizzes only for grade, did not improve learning	Sought to help instructor identify and address student pain-points
	Group Work (VL – students divided into groups of 10 and solved problem)	Students expressed it was helpful, but no improvement to exam scores	Sought to help students learn how to complete problems
	TA training (SP – TAs trained to provide constructive feedback)	Big success, number of students in faculty office hours reduced and able to offload some review sessions to TAs. Students expressed gratitude toward TAs.	In prior semesters students not motivated to go to TAs, they found TAs unprofessional, unprepared.
	Motivate students (PA/SP – provide examples of past success)	Presented experiences from past students and charts on how to pass/fail class. Students were interested but unclear as to effect.	Students had asked how to succeed in class
	Constructive feedback (SP/EA – provide encouragements and affirmations)	Students responded well, made them more comfortable with asking questions	Sought to help students participate more in class
	Test Anxiety (EA – exam review sessions, encouragement to attend office hours)	Students attending office hours, positive feedback and encouragement provided. Emailed struggling students.	Student stressed out on quizzes and affected performance. Sought to help students calm down.
2	Structuring Skill (PA – broke up big problems into smaller steps, small quizzes in LMS)	Students seemed to like, but some thought took too long to go through problem.	Thought it would help students be able to complete complex problems

Course Number	Teaching Strategies	Reflection	Choice
	Group Work (PA/SP – in class group work, contract for groups)	Group contract helped remove complaints about non-cooperating members. Difficulty in getting students to actively participate in class	Wanted to bring in more active learning and get students to work with each other.
	Rapport (EA – modified LMS site to make more navigable and personal)	Students liked modified site and personal touches.	Students complained about previous site
3	Hybrid learning (PA – pre-class reading and homework)	Class operated smoothly, but hard to tell if students were completing textbook homework problems themselves	Wanted to provide more time for active learning in class
	Active learning (PA/VL/SP – students complete homework problems in class)	Mixed engagement in-class, limited student-to-student talking or asking professor questions during class. Student just interested in getting homework done. Overall class grades remained similar to previous semesters.	Wanted to get students more engaged in homework by working together and with instructor
	Rapport (EA – provide time for students to ask questions in class)	Was able to have some good conversations about material	Wanted to connect more with students
4	Active Learning (PA/VL/SP – polling questions, collaborative white board, breakout rooms, step-by-step examples)	It worked well. Polling questions were simple and short that worked well in online format. Helped keep students engaged. Breakout rooms worked well in some cases. In others students zoned out and did not participate.	Allowed students to participate more in the classroom. The ideas appealed to me as an instructor.
	Guest Speaker (VL – former student to talk about career path)	Student got to see a possible career path, but difficulties in finding a guest speaker	Seemed straightforward and beneficial to students
	Constructive feedback (SP – revised rubrics and used online chat program for quick feedback)	Worked really well, fewer students missing points over required items. Students liked chat and felt comfortable using.	Thought it would help students. Chat program helped students more actively participate
	Rapport (EA – chatting with students, turning on webcam)	Enjoyed it. Helped provide opportunity to build relationship in online class	Difficult to get to know students in online class

Course Number	Teaching Strategies	Reflection	Choice
5	Hybrid learning (PA– pre-recorded videos, in-class quizzes)	Worked very well, Students felt information easier to digest, helped offload burden of going over easier information in class	Helped to provide more class time for active learning, break up course material, and reduce instructor fatigue
	Active learning (PA/VL/SP – group problem solving and in-class quizzes)	Students felt more connected to material and engaged with each other and professor. In-class quizzes on pre-recorded information encouraged students to prepare	Able to engage with students one-on-one in class and provide clarifying answers right away
	Demonstrating skills (VL – worked problems in class that presented error paths)	Problems scaffolded and error paths discussed. Helped students understand problem.	Able to demonstrate complex problems
	Rapport (EA – gather student comments about how class is going)	Able to address problem or misconceptions in class, students seemed to like that their voices were heard	Wanted to evaluate how course was going mid-semester
	Test anxiety (EA – open-ended positive question on front of exam)	Students said they liked and feel calmer going into exam	Wanted to address student's emotional state
6	Group work (PA/SP – real-life case study with prof. as group member)	Students seemed to like approach but were uncomfortable with prof. as group member.	Wanted more interaction with students, connection to real-life and why they are learning a topic
	Motivate students (PA/SP – short 5-min interactive sessions on course topic)	Able to have interaction with asynchronous course, students seemed to like	Wanted more interaction with students
	Guest Lecture (VL – several guest lectures by URM speakers)	Hard to measure	Wanted to help URM students to see potential for success
	Test Anxiety (EA – provide clear framework for exam)	Students liked the transparency, felt it helped reduce their stress	Wanted to help student perform better on exams
7	Peer Learning Assistants (VL/SP – peers helped to show success strategies, provide constructive	Worked reasonably well. Difficulty in getting peers trained to provide high quality feedback. Took more time to organized than previously thought.	Wanted students to connect with senior level students. Relieve some teaching burden.

Course Number	Teaching Strategies	Reflection	Choice
	feedback, friendly connection)		
	Guest Speakers (SP – guest speaker in game show – What's my Line?)	Helped to showcase career options. Students seemed to interact and participate well with guest.	Wanted engaging activity so students can participate with guest.
	Test Anxiety (EA – talked about exam anxiety issues)	Worked well. Students seemed to like and were more relaxed on exam.	Wanted to address test anxiety in freshman course

Almost all of the faculty (6/7) chose to use hybrid learning / active learning / group work in their courses. These strategies relate to the social cognitions of vicarious learning and mastery experiences sources of self-efficacy [11]. The common theme behind the choice was that faculty thought it would help students engage in class and learn better how to solve complex engineering problems. The faculty members' views on the success of the strategy were mixed. Faculty from courses 4 and 5 indicated that they felt it was working well in the class and this compares similarly to previous research [3], [8]. However, faculty from courses 1 and 3 felt like the student were only completing the group work in class to get it done and did not see improvement in the class grades.

Another popular strategy was to address test anxiety and build rapport in the class with all the faculty selecting to do something in this area to increase emotional arousal social cognition The common theme was that faculty wanted to build connections with the students and to address their emotional state. Most of the faculty felt this strategy worked well in the class.

Other strategies were also common. Guest speakers were used by 3 of the 7 faculty because they thought it would help students see potential future success as an engineer, but the impact on the students was hard to measure. Strategies to motivate students were used by 3 of the 7 faculty as well. The faculty did this by showing students ways to succeed in class. Methods to provide more constructive feedback were also used by 3 of the 7 faculty. One faculty member used a chat program for feedback while another utilized peer mentors.

Overall, the choice of teaching strategies used was focused on the desire of faculty to help students improve their learning. While many faculty choose similar strategies, each tailored the choice and strategy to their own class. However, even though some of the strategies used were similar not all faculty felt that strategy worked well in their class or the impact of the strategy was hard to measure. Though it was at times hard to measure, the results of success are comparable to past meta-analyses conducted that demonstrates improved student engagement.

In-class observations and student survey responses

To determine if students acquired knowledge or learned the course material with the new teaching strategies, the research team conducted class observations and students completed a survey after the observed classes.

The questions in the short survey assessed if students understood the class materials and the coding results are presented in Table 5. Based on the answers to the question (Q1) "What was the most important thing that you learned today," 226 answers were analyzed. A total of 201 statements reflected that the students understood the class contents or materials and 25 responses gave incorrect descriptions of class contents. No student claimed they were not sure what the lesson was talking about.

Based on the next question (Q2) "What is the muddiest point still remaining after today's class?" we received 222 answers from the six courses. A total of 176 statements indicated that students had questions related to lecture materials that were taught., 19 statements had concerns which did not pertain to the lecture being taught, and 27 responses indicated that students did not have confusion.

Table 5: In Class Student Survey

Course Number	Q1				Q2			
	Not sure	Understand materials	Incorrect answers	Reponses /enrollment	Did not pertain to the lecture	Pertained to the lecture	Nothing	Reponses/ enrollment
1	0	99	14	113/240	4	103	5	112/240
2	0	23	3	26/42	2	16	8	26/42
3	0	8	0	8/25	2	4	2	8/25
4	0	18	0	18/100	2	15	1	18/100
5	0	17	2	19/39	0	17	1	18/39
7	0	36	6	42/54	9	21	10	40/54
Total Responses	0	201	25	226	19	176	27	222

Table 5 indicates that most of the students completing the survey (86% to 100%) correctly identified the main topic of the class session. These high numbers indicate that the learning strategies used in the class were at least in part successful in helping students know what they were learning. However, the number of students completing the survey compared to the class enrollment was relatively low (ranged from 18% to 61%). It is possible that those students who had less idea of the class objectives on that particular day may not have completed the survey. For question 2, most students indicated a point that they were still unclear about that pertained to the lecture on that particular day. However, greater percentages of students had points that did not pertain to the lecture (e.g., 25% for class 3) or said that they did not have questions or uncertainty (e.g., 31% for class 2). The highest percentages of muddy points that pertained to the lecture were in class 1 (92%) and class 5 (94%) indicating that these classes may have been more successful in relating the class material.

The means and modes of the 5-point scale that students used to assess class effectiveness (SQ1) and class activity (SQ2) are presented in Table 6. The means of both questions were high (3.68 or greater) indicating that the students felt the overall class and activity were helpful in

learning the class material. For the question "how effective was today's class in helping you to learn course materials," the average scores from courses 1, 2, and 4 were higher than 4.00. For the question "how effective was the class activity in helping you to learn course material," course 7 had the highest mean score 4.33, and all other courses' mean scores were lower than 4.00. Courses 3 and 7 had a higher mode for SQ2 than SQ1 indicating that the students felt the class activity was more effective than the overall class session.

Table 6: Mean of Ranking of Course and Activity Effectiveness for Each Course

Course No.	SQ1		SQ2	
	Mean	Mode	Mean	Mode
1	4.10	4	3.94	4
2	4.00	4	3.88	4
3	3.80	4	3.90	5
4	4.13	4	3.86	4
5	3.95	4	3.68	4
7	3.66	4	4.33	5

*5-point scale with 1 = not effective and 5 = very effective

To evaluate students' experience and engagement during the class sessions, the research team conducted class observations. Evidence from observation notes is summarized in Table 7. Table 8 compares the faculty reflection, SQ2 response, and student engagement for the teaching activity to evaluate possible correlation. The data seems to indicate that the engagement and energy of the class correlates to the faculty member's reflection that the activity was working and students' survey responses to the effectiveness of the activity

Table 7: In-Class Observation Descriptions

Course Number	Teaching Activity	Students Engagement Description*	Task Instruction**	Observer Notes
1	Students used the app iClicker to interact with instructors, and earned class participation points	Engaged	Well defined	Good interactions with students. Students paid attention and answered questions.
2	Instructor gave lectures and presented practice problems	A little Engaged	Well defined	Although the faculty member wanted to use group work, there was little working in groups to solve the problem. Students mostly waited for faculty to answer.

Course Number	Teaching Activity	Students Engagement Description*	Task Instruction**	Observer Notes
3	Doing problems with worksheet. Students can discuss questions together and ask instructor's help.	Engaged	Well defined	Students completed problem sheet at end of class, but did not actively participate with each other. Simply trying to complete and leave.
4	Lecture with group problem solving using jam board	Engaged	Well Defined	Students participated well in online class. Atmosphere was welcoming.
5	Problem solving activity	Very Engaged	Very well defined	Faculty member created very energetic and welcoming atmosphere that encouraged student participation in class and during group work
7	Guess the line of work of guest (Students ask yes/no questions to determine line of work.)	Very Engaged	Very well defined	Students very engaged. Faculty kept up energy in class.

*Students engagement descriptions: not engaged, a little engaged, moderately engaged, engaged, very engaged

**If the task was well defined response options: not well defined, well defined, and very well defined.

Table 8: Comparison of faculty reflection and student engagement on learning activity

Course	Faculty reflection	SQ2* Mean	Student Engagement
1	Did not improve learning	3.94	Engaged
2	Difficulty in getting students to actively participate in class	3.88	A little Engaged
3	Mixed engagement in-class, grades remained similar	3.90	Engaged
4	It worked well.	3.86	Engaged
5	Worked very well. Students felt more connected to material and engaged with each other and professor.	3.68	Very Engaged
7	Students seemed to interact and participate well with guest.	4.33	Very Engaged

* SQ2 question: How effective was the activity "(strategy name)" in helping you to learn the course material?

From Table 8, we can see that faculty reflection indicated a positive impression in courses 4, 5, and 7. For course 4, students also gave a high score (3.86/5.00) to the SQ2 question, and the class observation showed that student engaged in the class. This indicated that the strategies "lecture with group problem solving using jam board" could help students get engaged and students feel this strategy is helpful. For course 5, the instructor and students found the "problem solving activity" helped students engage with classmates and the professor with a high score of SQ2 was (3.68/5). For course 7, the scores of SQ2 (4.33/5) indicated that the class activity was the most beneficial, and the instructor's reflection and class observation showed that the class was very engaged as well. This displayed the strategies the game "guess the line of work of guest" help students engage the class and also learn the engineering course materials.

From Table 8, for course 1 and 3, the strategies the faculty used were "students used the app iClicker to interact with instructors, and earned class participation points" and "doing problems with worksheet, discussing questions with classmates and asking instructor's help". Although two faculty described these two strategies did not help with improving students' grades, students thought these two strategies helped them learn course materials (SQ2 for course 1=3.94, SQ2 for course 3=3.90) and made them feel engaged.

From Table 8, we can see faculty considered the strategies "giving lectures and presenting practice problems" did not get students to actively participate in class, and students did not show very much engagement in the classroom either. The SQ2 score was high (3.88/5), but this strategy did not help students get involved on that class.

In addition, for each observed course, our team paid attention to the strategies related to the four sources of learning experiences. Table 9 depicts if faculty used the strategies to encourage performance accomplishments, vicarious learning, social persuasion or verbal persuasion, and emotional arousal in classrooms when researchers observed. In Table 8, "yes" indicated that those strategies were used, and "no" means it was not used in the observed class. For example, in course 1 (C1), instructor provided real world examples, used a positive reinforcement, and the feedback to students is constructive.

Table 9: In-class observation of learning strategies

Source	Strategies	Course						Total *	Total *
		1	2	3	4	5	7		
SP	Provides real world examples	Yes	Yes	Yes	Yes	Yes	Yes	6	17
	Use of positive reinforcement	Yes	No	Yes	Yes	Yes	Yes	5	
	Feedback is constructive	Yes	Yes	Yes	Yes	Yes	Yes	6	
	Other motivational strategies						Yes		
PA	Students have the opportunity to practice the skill / task.	Yes	Yes	Yes	No	Yes	No	4	14
	Active learning strategies are used in class	Yes	No	Yes	Yes	Yes	Yes	5	
	Class problems are scaffolded	Yes	Yes	Yes	Yes	Yes	No	5	
	Other:					Yes			
VL	Students watch problem solving activities that demonstrate the skill / task	Yes	Yes	No	Yes	Yes	No	4	10
	The demonstrations are effective in modeling the skill / task.	Yes	Yes	No	Yes	Yes	No	4	
	Peers, guests, or group work is used to provide examples of completing skill /task	No	No	No	No	Yes	Yes	2	
	Other:					Yes			
EA	physical space set up is appropriate for the learning activities implemented	Yes	Yes	Yes	No	Yes	Yes	4	15
	Faculty attempts to build rapport with students	Yes	Yes	Yes	Yes	Yes	Yes	6	
	Emotional state (test anxiety, etc.) is acknowledged	No	No	Yes	No	Yes	No	1	
	Sets overall positive class environment	Yes	Yes	Yes	No	Yes	Yes	4	
	Other:					Yes			
	Total*frequency	11	9	10	8	16	9		

*Total meant the frequency of Yes.

From Table 8, most of the strategies (f = 17) skills used by instructors belongs to social persuasion or verbal persuasion. For example, when students asked questions, an instructor provided specific examples to help comprehension. Strategies related to emotional arousal had the second highest frequency (f= 15). For example, one instructor tried to build a positive learning atmosphere by noticing students were still writing and reconsidered the time management. However, it was worth considering that only one instructor detected students' emotional state.

Conclusions

Faculty members participating in this program made several beneficial changes to their classroom teaching strategies. The choice of strategy was often based on what the faculty member thought would most benefit the students and would work well in their classroom. Most faculty chose to use a combination of hybrid learning, active learning, and group work in order to

engage students in problem solving during class. Methods to motivate students, guest lectures, and methods to provide more constructive feedback were also popular. However, even though some of the strategies used were similar not all faculty felt that strategy worked well in their class.

Responses from a student survey indicated that students felt the class session (3.94/4) and teaching activity (3.93/4) were effective in helping them learn the class material. Based on the classroom observations, the classes where faculty thought the strategy was working well were also the classes in which the students seemed most engaged in the activity. The results indicate that improvements to teaching strategies can have positive effects on the faculty member's and student's view of learning. However, even with the same or similar strategies, there are differences in effectiveness. Additional work is needed to determine what makes a particular strategy effective.

Limitations

This paper did not report students perceived self-efficacy and outcome expectation ratings, which were also surveyed, but not yet analyzed. Future research can compare student ratings with teaching strategies. In addition, faculty members self-reported the reflections regarding strategies they adopted, and the reflections were summarized and interpreted by the research team.

Future Work

Much of the data presented in this paper is qualitative in nature. The research team is currently analyzing data collected using instruments on self-efficacy [15], [18], engineering positive outcome expectations [19], and engineering persistence intentions [20]. Additional open-ended questions were also included on the student's perceptions of the helpfulness of strategies in each of the four sources of social cognitions. This additional data analysis will give further insights on which strategies were the most beneficial in impacting student learning.

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