SHIFTING PEDAGOGICAL PARADIGMS: THE ACTIVE LEARNING IN ENGINEERING PROGRAM

A Dissertation

by

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ABSTRACT

Engineering education has a long and well-researched history; however, recent declines in the number of undergraduate students entering and matriculating through to graduation has commanded the engineering education community's attention. To help counter the declining number of students entering and persisting in engineering, an engineering education reformation is underway where instructors use their engineering mindsets to transition from knowledge transmitters to designers of knowledge creation, learner-centered environments. However, many engineering instructors are not trained in such methodologies. As a result, engineering colleges and departments have made efforts to assist instructors in developing such pedagogical capabilities and efficacy.

Texas A&M University's College of Engineering (CoE) sought to modernize their facilities as a means of supporting pedagogical change, which included innovatively designed learning spaces in the new Zachry Engineering Education Complex. The updated learning spaces catalyzed the need to provide instructors with faculty development to assist their transition into the newly renovated Zachry spaces, encouraging them to incorporate more evidence-based teaching strategies as a way of moving towards the College's strategic goals.

Texas A&M's CoE sought assistance to create a faculty development program to accelerate faculty's use of the learning spaces Zachry affords. The Active Learning in Engineering Program (ALEP) was developed as a partnership between the CoE, the Center for Teaching Excellence (CTE), and Instructional Technology Services (ITS). The ALEP aimed to prepare and support engineering instructors as they transition pedagogical paradigms into one that foster more learner-centered instruction for the newly designed Zachry. This study evaluated the effectiveness of the ALEP. Its results indicate the didactic instructional profile remains common across undergraduate engineering regardless of the substantial amount of support for more impactful evidence-based teaching strategies. Though this is the case, slight indicators of improvement can be detected, while not statistically significant, challenging institutions and disciplines to relook at policies and practices potentially perpetuating this status quo. Specifically, the researcher would recommend institutions reflect on and revise their pre-service and in-service faculty development for future and current instructors, incentivize and reward instructor’s implementation of evidence-based teaching practices, and the use of a research-based holistic framework for the review of teaching.

DEDICATION

To my husband, Josh, for being my forever in all things – my forever supporter, cheerleader, rock, and whip-cracker. You believe in me even when I doubt.

To my kiddos, AGS1 and AGS2, for providing a constant source of motivation and devotion, as well as being amazing study buddies.

To my boss lady, Debra Fowler, for opening doors I never knew existed but brought me to a place I never want to leave.

To my dad, Michael Rohr, for encouraging me to always pursue my dreams…even if he didn't get the chance to see this one come to fruition.

Last and most importantly, to God…this Ph.D. lives out Philippians 4:13 – I can do all things through Christ who strengthens me.

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CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by dissertation committee consisting of Dr. Michael de Miranda, Dr. Cheryl Craig, Karen Rambo-Hernandez, and Dr. Hersh Waxman of the Department of Teaching, Learning, and Culture at Texas A&M University; Dr. Sunay Palsole of the College of Engineering at Texas A&M University; and Dr. Debra Fowler of the Department of Educational Psychology at Texas A&M University. All work for the dissertation was completed independently by me under the supervision and advisement of Drs. Michael de Miranda and Debra Fowler.

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NOMENCLATURE

ALEP	Active Learning in Education Program
CoE	Texas A&M University’s College of Engineering
COPUS	Classroom Observation Protocol for Undergraduate STEM
CTE	Texas A&M University’s Center for Teaching Excellence
ITS	Texas A&M University’s Instructional Technology Services
STEM	Science, technology, engineering, and mathematics
TAMU	Texas A&M University
TPI	Teaching Practices Inventory
Zachry	Zachry Engineering Education Complex

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CHAPTER I

INTRODUCTION

Engineering faculty at research-intensive higher education institutions serve in many roles; two salient are researcher and instructor. These faculty members come to academia as disciplinary experts with years of research experience in their respective disciplines. While academia requires disciplinary training and expertise, the same is not always the case for formal pedagogical training and expertise. A lack of formal pedagogical training results in the potential for engineering instructors to default to familiar teaching strategies, mainly a traditional lecture-based approach. This pedagogical pipeline perpetuates outdated and less effective teaching strategies being used in today's engineering classrooms (Stains et al., 2018).

Engineering, as a discipline, melds together multiple sciences, such as chemistry and physics; advanced mathematics; technology; and design. An engineering undergraduate program immerses a learner in rigorous and abstract experiences and courses to prepare them to enter the profession. As an engineering instructor, a faculty member designs their classroom learning setting in the manner of their choosing, pulling from their disciplinary expertise and pedagogical background to ensure their engineering students achieve the learning outcomes set forth. With engineering's interdisciplinary nature, a traditional lecture-based course approach may not net the maximum potential level of student learning. James Duderstadt (1999), former University of Michigan President and professor of nuclear engineering, provides a rousing call to action given to engineering instructors and engineering program developers. He states, "It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments” (p. 7).

Cognitive psychology research is generating evidence that novice learners require an active environment, rich in multiple and varied material representations, where learners can interact with the content in order to construct meaning and make connections (Ambrose et al., 2010; Bransford et al., 1999; Piaget, 1926; Vygotsky, 1978). These research findings on how people learn catalyzed transformations in both pedagogical practice and learning spaces design. Learning spaces are evolving from traditional stadium-like rows of seating with front-and-center lecterns to open areas equipped with interactive work areas, writeable spaces, and multiscreen projection technologies. The combination of changes in both cognitive psychology and in learning spaces means that the built architecture should not dictate the instructional environment of the class (Laporte & Shields, 2018). Therefore, there is an increasing need for instructors to employ non-traditional, evidence-based teaching strategies, regardless of the learning space.

Several studies have provided evidence on the efficacy and student learning benefits of evidence-based teaching strategies (Hake, 1998; Freeman, 2014). However, many studies have reported that engineering instructors are translating research into actual classroom practice at a very slow rate (Finelli et al., 2014; Froyd et al., 2017; Handelsman et al., 2004; Henderson & Dancy, 2011). Handelsman et al. (2004) hypothesize that this slow innovation diffusion is due to science faculty’s lack of awareness about effective teaching strategies, distrust of educational research, and, therefore, an unease in learning new approaches to teaching, which perpetuates the slow adoption of effective teaching strategies. Henderson and Dancy (2011) found that faculty are generally aware of evidence-based teaching strategies, and are interested in some implementation, but struggle with several situational barriers such as content coverage expectations, perceived lack of instructional time, student resistance, department norms, and physical classroom limitations.

Active Learning in an Engineering Education Complex

Engineering education has a long and well-researched history; however, recent declines in the number of undergraduate students entering and matriculating through to graduation has commanded the attention of the engineering education community (Felder et al., 1998; Seymour & Hewitt, 1997). Engineering, as is the case with many science, technology, engineering and mathematics (STEM) disciplines, the content and concepts build on one another. Fundamental engineering instruction typically supports learning with concrete conceptual representations. As students progress through a program and mature developmentally, instruction is scaffolded from concrete to more abstract conceptual representations, which requires the learner to rely more on his/her mental models and conceptual understanding (Piaget, 1952). As concepts become more abstract, the cognitive load increases and becomes more mentally taxing for the learner. Traditional teaching strategies, like lecture, provide little cognitive support or relief for a learner struggling to keep up with the increasing cognitive demand. On the other hand, non-traditional methods assist learners in making more abstract concepts explicit, thus allowing for deeper learning to occur. This helps students build and transition learning from the concrete to the abstract. Pedagogy, an instructor’s teaching strategies used in the classroom, has been identified as a leading factor in students’ lack of persistence in engineering (Felder et al., 1998; Seymour & Hewitt, 1997).

To help counter the declining number of students entering and persisting in engineering education, as well as address James Duderstadt (1999) rousing call to action, an engineering education reformation is underway where instructors use their engineering mindsets to transition from knowledge transmitters to designers of knowledge creation, learner-centered environments. However, many engineering instructors are not trained in such methodologies. As a result, engineering colleges and departments have made efforts to assist instructors in developing such pedagogical capabilities and efficacy.

In order to offer a modernized learning environment, Texas A&M University recently constructed 32 new active learning spaces, termed learning studios, in the redesigned Zachry Engineering Education Complex (Zachry). Figure 1 shows a side-by-side comparison of the original Zachry Building prior to redesign and the newly completed Zachry. The updated classroom spaces afford instructors a more dynamic, flexible, technology-enhanced learning space to facilitate the use of modern learning, non-traditional teaching techniques. The new Zachry Building’s objective was to further transform engineering education, “revolutionizing the way” instructors deliver education by providing more learner-centered instruction (Texas A&M University Engineering - Zachry Engineering Education Complex, 2019). Zachry provides a physical learning environment that is geared for a cognitive-apprenticeship approach where instructors, the disciplinary experts, make the learning explicit for students, who learn as apprentices through observation, imitation, and modeling (Collins et al., 1987). Classrooms are designed to become learning environments built on community with instruction transitioning from transactional or transmission sites to knowledge sharing and knowledge creation communities, aligning with the four dimensions Collins et al. (1987) promote in their cognitive apprenticeship framework: content, method, sequence, and sociology.

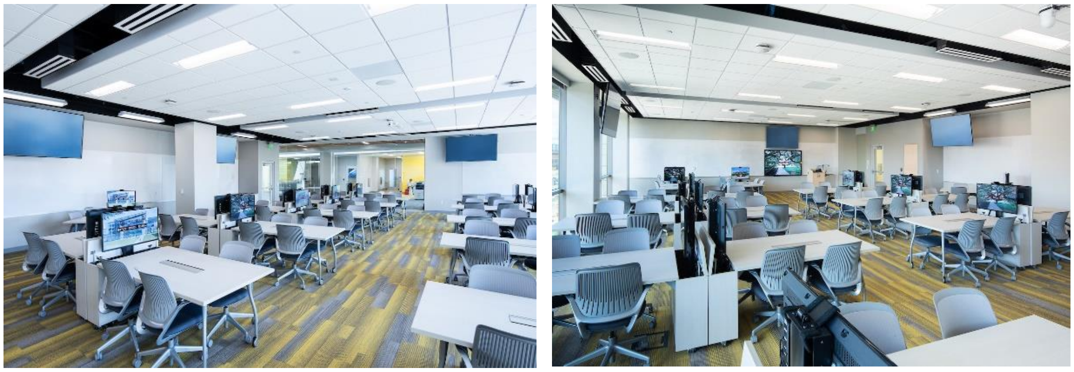
Figure 1

Original Zachry Building Prior to Redesign and the Newly Completed Zachry (Reprinted from Texas A&M University Engineering Photo Repository, 2019)

Each of Zachry's 32 rectangular learning studios is designed for community building, constructed with internal glass walls to intentionally create a transparent and open classroom environment. Figure 2 shows an example of Zachry's new completed large learning studio, ZACH 444. A ThinkHub monitor is mounted along one of the learning studio's walls, serving as the main instructional area. Several other large displays are mounted around the room's ceiling perimeter so that, regardless of where in the room a student is sitting, there is a display close by for viewing ease. Each learning studio is equipped with rectangular student technology worktables of four. There are 18 large learning studios with 24 technology worktables of four (i.e., a 96-person learning studio), and 14 small learning studios have 12 technology worktables of four (i.e., a 48-person learning studio). Each student technology worktable has its own 32-inch monitor that can be raised or lowered by either the instructor or the students working at the table. Each ThinkHub has interactive and collaborative capabilities allowing the instructor to push content out to the individual table monitors, as well as the other mounted displays. Zachry's learning studios use AirConnect streaming software to provide students the capability to push wirelessly content from their personal devices to the individual table monitors, with up to four devices projecting to a table monitor at one time. The instructor can also use the ThinkHub to project different table monitor displays either to the ThinkHub, the other mounted displays, and/or to the other individual table monitors.

Figure 2

An Example of Zachry's New Completed Large Learning Studio (ZACH 444; Reprinted from Texas A&M University Engineering Photo Repository, 2019)



Zachry's modernized learning environment differs greatly from the many more traditional campus learning spaces. Texas A&M's College of Engineering (CoE) sought assistance to create a faculty development program to accelerate faculty's use of the learning spaces Zachry affords. The Active Learning in Engineering Program (ALEP) was developed as a three-way partnership between the CoE, the Center for Teaching Excellence (CTE), and Instructional Technology Services (ITS). The ALEP, anchored in research, initially aimed to prepare and support engineering instructors as they transition pedagogical paradigms into one that foster more learner-centered instruction for the newly designed Zachry. When the ALEP's components and curriculum were established, the Program's purpose expanded to assist any and all interested engineering instructors in adopting new pedagogical practices for use in a new state-of-the-art learning studio or a more traditional classroom.

The ALEP's Program Purpose

The ALEP aims to: (a) aid engineering instructors in assimilating evidence-based teaching strategies into their existing pedagogical paradigms, and (b) prepare and support all-levels of instructors from diverse engineering departments as they focus on creating a learning environment much different than that many instructors are accustomed. The ALEP began when Zachry was still under construction; therefore, the Program utilized a prototype classroom as a technology testbed and for instructor preparation before the building opened for classes in Fall 2018. This immersive faculty development approach assists instructors build the confidence and competence necessary to implement more non-traditional, active learning-type teaching practices.

The ALEP was designed to avoid what Henderson, Beach, and Finkelstein (2011) identified as two common, but ineffective, change strategies – 1) "best practices" dissemination and 2) "top down" policy-formation - to influence pedagogical change.

Instead, propagation methods were intentionally used to meaningfully and frequently connect with early adopters to introduce them to an instructional mindset and interactively create a strong implementation plan (Froyd et al., 2017). Though the modernized Zachry catalyzed the ALEP's development, assisting all engineering instructors in adopting a more learner-centered approach to teaching anchored the faculty development offered. The ALEP endeavors to empower engineering instructors to implement evidence-based teaching strategies, with the ultimate goal being better student learning.

The ALEP is rooted in the engineering discipline as a way to engage engineering instructors in faculty development and talks about learning, evidence-based teaching strategies, and learner-centered instruction. The ALEP's components include online modules, workshops, community of scholar events, technology training, and practice teaching sessions. This component variety is designed to meet the wide array of participant faculty development and interest needs (Ramsay and Dick, 2019). The effectiveness of a new teaching strategy is influenced by the instructor's fidelity of implementation, use of technology, and use of space to enhance student learning, which has the potential to be especially salient due to the new Zachry's updated teaching space design and large amount of classroom technology (Baepler et al., 2016). This presents both an opportunity and a challenge for program implementation with respect to those instructors who may not be inclined for upskilling or feel they have the time to avail to faculty development. Cognizant of this, there is a growing need to research preparing and supporting instructors as they transition pedagogically into an active learning environment, whether it be for implementation in an active learning space, such as those in Zachry, or whether it be in a more traditional learning space.

Problem Statement

The diffusion of innovation, such as Zachry's modernized learning environment, is typically slow in many STEM programs (Finelli et al., 2014; Froyd et al., 2017; Handelsman et al., 2004; Henderson and Dancy, 2011). Though slow, the idea of learner-centered instruction is taking hold and the adoption of non-traditional, evidence-based teaching strategies is happening as targeted efforts propagate and accelerate faculty's pedagogical transition (Finelli et al., 2014; Froyd et al., 2017). Several of these efforts were considered in ALEP's organization and development.

The ALEP used the phrase *active learning* as an overarching, all-encompassing phrase used to discuss evidence-based teaching strategies. Current trends in faculty development indicate the need for disciplinary expertise. Considering the disciplinary perspective emphasized in both Handelsman et al. (2004) Scientific Teaching and Wieman's (2017) Science Education Initiative, the ALEP frames active learning through a STEM lens as much as possible. The ALEP also incorporates a version of Wieman's (2017) Science Education Specialist as a way to demonstrate to engineering instructors the validity and reliability of the pedagogical information and data shared.

To aid in conceptual understanding of evidence-based teaching strategies, the ALEP provides participants with the following three STEM-focused active learning definitions. Hake (1998), a physicist and the father of interactive engagement, defined it as "those [methods] designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities" (p. 2). Prince (2004), a chemical engineer and engineering education researcher, generally defined active learning "as any instructional method that engages students in the learning process” (p. 1). Felder and Brent (2016), seminal researchers in engineering education, defined active learning as “anything course-related that all students in a class session are called upon to do other than simply watching a lecture and taking notes” (p. 113). The ALEP explained active learning requires students to participate in meaningful, purposeful, minds-on learning activities in the classroom. This definition is deliberately broad to help participants grasp that active learning is a broad category of evidence-based teaching strategies that aim to get students’ minds actively engaged during class. The ALEP provided participants with a one-page resource further unpacking active learning, its implications for student learning, and basic steps for getting started using active learning in the classroom (see Appendix A).

Many studies have found that students engage more with content and show enhanced learning in active learning classrooms (Felder & Brent, 2009; Freeman et al., 2014; Hake, 1998; Lord et al., 2012; Michael, 2006; Weimer, 2013). Researchers have also found that student learning shows an appreciable measure of improvement when assessed using concept inventories even when students reported on surveys they had not learned (Reimer et al., 2016). A comprehensive meta-analysis by Freeman et al. (2014) provides strong evidence in support for the use and adoption of active learning strategies. Their meta-analysis across 225 studies concluded that students in traditional lecture courses were 1.5 times more likely to fail than those in active learning courses. Each of the other included studies will be reviewed in detail within the Chapter 2 – Literature Review section.

Study Purpose

Zachry's learning studios were intentionally designed and technology-enhanced to facilitate the instructor's use of non-traditional, cognitive apprenticeship strategies to help improve student learning. The instructor serves as the disciplinary expert, whose instructional role it is to make the learning explicit for students, who learn as apprentices through observation, imitation, and modeling (Collins et al., 1987). The ALEP has been designed to help instructors take incremental steps towards the adoption of more non-traditional, learner-centered teaching strategies. Though Zachry catalyzed the ALEP's creation, it serves as only one of the many instructional spaces the ALEP helps instructors work within as they begin to think about adopting more evidence-based teaching strategies.

The study evaluated the effectiveness of the ALEP, a program designed to prepare and support engineering instructors transition to a more learner-centered pedagogical paradigm by incorporating evidence-based teaching strategies. Research in faculty development that brings lasting pedagogical change is needed and will remain as such as more active learning spaces, like those found in the Zachry, are built and operational. The study will serve to improve the quality of the current ALEP for application in future semesters, as well as dissemination to a larger population an impactful and sustainable faculty development model aimed at effective instructor preparation in utilizing evidence-based teaching strategies and active learning spaces. ALEP serves as a model for future faculty development programming.

Program Learning Outcomes (PLOs)

The ALEP created six overarching program learning outcomes to drive the faculty development content, activities, and products. As the ALEP's components and curriculum were developed, these six outcomes anchored what was emphasized in the online modules, workshops, community of scholar activities, technology training, and practice teaching sessions. After successfully completing the Program, instructors will be able to:

1. Define active learning and explain its benefits,
2. Identify and demonstrate active learning strategies,
3. Identify and adopt technology tools that facilitate active learning,
4. Analyze the effectiveness of the application of an active learning technique,
5. Construct a plan to incorporate at least two active learning strategies into a course,
6. Structure a course and course syllabus to include active learning.

Program Procedures

This study's intervention was the ALEP. The ALEP was created, implemented, and managed by a project management team with members from all three Texas A&M partnering units – CoE, CTE, and ITS. The ALEP offered five different faculty development types, for a total of eight individual events, over the course of the Fall 2017, Spring 2018, and Summer 2018 semesters for interested engineering instructors to participate. Each ALEP faculty development type is listed below, including when it is offered:

1. Pre-work – a pre-ALEP Qualtrics questionnaire was offered via the Program's eCampus Organization beginning late Fall 2017 and closed at the start of Workshop #1. Online instructional technology modules (4), also housed in the Program's eCampus Organization, were continuously offered beginning late Fall 2017.

2. Face-to-face workshop sessions (3) – offered in Spring 2018
3. Community of Scholars sessions (2) – offered in Spring 2018
4. Technology training clinics – offered Spring and Summer 2018
5. One-on-one in-classroom practice teaching sessions – offered August 2018

The ALEP instructor participants were encouraged to participate in all Program faculty development offerings. The technology training was the only required component for those teaching in the updated Zachry.

Research Questions

The study is guided by the following research questions:

1. Are there differences between the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors? Are there changes within the classroom teaching strategies utilized by ALEP instructor participants after Program participation?
2. Does an ALEP instructor participant's Teaching Practices Inventory (TPI) score relate to his/her Classroom Observation Protocol for Undergraduate STEM (COPUS) observation score?
3. Does the ALEP instructor participant's post-ALEP COPUS observation score relate to his/her ALEP participation intensity or his or her pre-ALEP COPUS observation score?

Study Significance

This study is significant as its results can be used to examine the effectiveness of a faculty development program aimed to prepare and support faculty transition pedagogical paradigms into those that engage and cultivate active student engagement in the classroom.

The findings from this study will inform the development of future faculty development opportunities based on significant overall, as well as individual, differences found. This study’s findings will: (a) assist instructors, researchers, educational developers, and administrators enhance their knowledge on how to purposefully design a faculty development program focused on instructor’s pedagogical practice; (b) support the assimilation of evidence-based teaching strategies into one’s teaching; and (c) be incorporated into future faculty development with Texas A&M University’s Innovative Learning Classroom Building scheduled to open in Fall 2020.

The researcher is interested in determining if the ALEP had a significant impact in shifting participating engineering instructors use of classroom teaching strategies. If it was significantly impactful, what can be gleaned and applied to future faculty development offerings to afford similar results. As active learning spaces become more prevalent on higher education campuses, this study will help the research learn from the ALEP in terms of supporting instructors confidently and competently transition into and harness the pedagogical intent of these spaces. These findings can then be disseminated within and across institutions who also look to invest in not only active learning spaces, but in adequately preparing and supporting their instructors to teach in these spaces.

Limitations

This study used a quasi-experimental design, conducted with an intact convenience sample of engineering instructor participants, at a single institution, Texas A&M, during a portion of the 2017-2018, 2018-2019, and 2019-2020 academic school years. Therefore, this study has limited generalizability, focusing more on quality improvement purposes.

Data for research question two was collected through a Teaching Practices Inventory questionnaire administered to only the ALEP participating engineering instructors, a subset of Texas A&M's engineering instructor population. The questionnaire was completed voluntarily and collected self-reported data. Data for research question one, two, and three was collected through classroom observations of ALEP participating engineering instructors and a comparison sample of non-ALEP engineering instructors, a subset of Texas A&M's engineering instructor population, using the Classroom Observation for Protocol for Undergraduate STEM. Instructor participation in classroom observations was voluntary; each individual classroom observation was completed by one of three different trained study observers. Any references or generalizations made to the Texas A&M's engineering instructor population is limited due to a lack of non-randomization in the study sample.

Additional study limitations exist regarding internal validity threats. Such internal validity threats include natural participant instruction maturation. This study was longitudinal in nature, so instructors naturally maturing in their teaching is a rival hypothesis to changes in practices. There was attrition in the number of ALEP instructor participants who completed the TPI from pre- to post-. Lastly, there was the potential selection bias in the treatment group participants, as this was the inaugural ALEP offering, and potential selection bias in the post-control group participants, as this was the first semester Zachry was open.

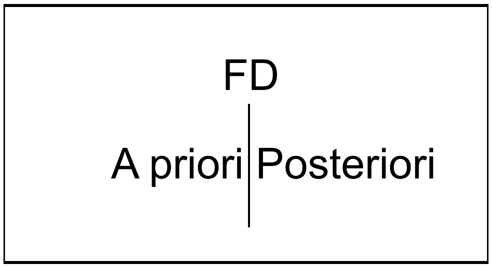
Assumptions

This study evaluated the effectiveness of the ALEP, a program designed to prepare and support engineering instructors' transition to a more learner-centered pedagogical paradigm by incorporating evidence-based teaching strategies. It was assumed: (a) faculty's adoption of evidence-based teaching strategies were not significantly altered from the beginning of the Spring 2018 semester until his/her participation in the ALEP, and (b) faculty's self-reporting of teaching practices was a truthful and honest representation of what he/she actually does with students in the classroom.

The ALEP focuses on a posterior issue. If faculty are going to be engineering educators, it is assumed they would participate in pedagogical faculty development before they begin teaching. This is not always true in all graduate programs. Once faculty begin their engineering educator role, pedagogical training gets added to their over burgeoning action items list. From this point, the only thing available to them is in-service pedagogical-focused faculty development. That in-and-of-itself is limiting for a multitude of reasons, one being it is not incentivized. It takes an institutional change, not just a faculty change. Figure 3 shows a schematic description of this assumption.

Figure 3

Study Context



Definitions of Terms

Key terminology used throughout this study are operationally defined as a basis for interpretation and comprehension.

Active learning: Teaching methods that require a student to be “minds-on” in the classroom; not passive learning.

ALEP: Active Learning in Education Program. A program designed to prepare and support engineering instructors transition to a more learner-centered pedagogical paradigm by incorporating active learning teaching strategies.

CoE: Texas A&M University’s College of Engineering

COPUS: Classroom Observation Protocol for Undergraduate STEM

CTE: Texas A&M University’s Center for Teaching Excellence

Engineering instructor: An instructor in higher education who teaches in one or more of TAMU’s engineering departments. These instructors may be of any level – professor of practice, academic professional track, or tenure track.

Evidence-based teaching strategies: Teaching strategies supported by research evidence.

Faculty development: Support TAMU’s educational mission through evidence-based professional development opportunities promoting proven and innovative instructional approaches aligned with faculty and student success.

ITS: Texas A&M University’s Instructional Technology Services

Learner-centered instruction: Teaching methods that shift the instruction’s focus from the teacher to the student.

Pedagogical practice: The teaching approach, including methods, strategies, and/or style, an instructor uses in the classroom to deliver content in support of student learning.

STEM: Science, technology, engineering, and mathematics.

TAMU: Texas A&M University. A land-grant institution located in College Station, Texas. It was founded in 1876 and currently serves over 60,000 students.

TPI: Teaching Practices Inventory

Zachry: Zachry Engineering Education Complex. In order to offer a modernized learning environment, Texas A&M University constructed 32 new active learning spaces, termed learning studios, in the redesigned Zachry Engineering Education Complex.

Researcher's Perspective

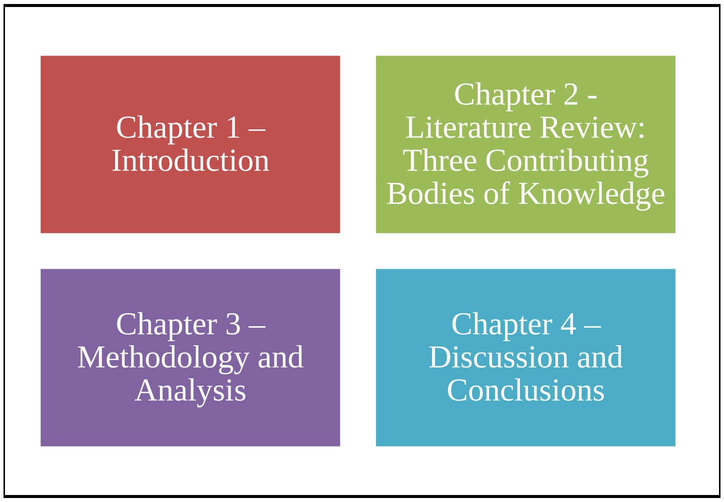
The lens through which a researcher looks at research provides a unique perspective and context. The following is the researcher's history as it pertains to this study. She is a teacher by trade, having earned a Bachelor of Science and Master of Education degrees in teaching related fields. The researcher spent nine years teaching math and science in K-12 public education, followed by an additional five years teaching preservice teachers in the Teaching, Learning, and Culture Department in TAMU's College of Education before starting work on her Ph.D. in curriculum and instruction with a concentration in teacher education. As part of her assistantship, the researcher had the opportunity to work as a graduate assistant for curriculum development in TAMU's Center for Teaching Excellence. Her work at the Center included the development of a new architectural engineering degree. The researcher is not an engineering disciplinary expert, but brings an expertise in curriculum and instruction, a strong pedagogical background, and a passion to enhance student learning to collaborate with engineering disciplinary experts. The researcher also brough tremendous organizational skills, helping to create, curate, and manage program resources. These experiences primed her as the CTE representative to assist CoE and ITS on the development of a program designed to aid engineering instructors in assimilating evidence-based teaching strategies into their existing pedagogical paradigms. Though there are many contexts to analyze the study's data, the research comes from an educational development perspective, drawing from the data ideas for modeling and framing future faculty development programming, as well as to disseminate findings at educational developers and engineering educations conferences and journals. It is this perspective that serves as this study's impetus.

Dissertation Outline

This dissertation will be organized into four chapters. Chapter I presents the study's introduction, Program purpose, Program rationale, Program of study, Program learning outcomes, Program procedures, research questions, assumptions, definition of terms, researcher's perspective, and study organization. Chapter II details the three seminal, contributing bodies of knowledge – teaching and learning, engineering education, and faculty development – providing the study's foundation aimed at preparing and supporting faculty transitioning their pedagogical paradigms into one that engages and cultivates students in an active learning environment. Chapter II also contains a section synthesizing the three contributing bodies of knowledge, thus detailing the ALEP's engineering faculty development literature foundation. Chapter III details the methodology by providing an introduction and study context, followed by an explanation of the research design; variables; participants; recruitment; study variables; instrumentation, including validity measures and reliability measures; treatment of the data; and research question specific details, including procedures, analytic approach, data analysis. Finally, Chapter IV provides a discussion and overall summary of findings, including conclusions, future faculty development implications, and recommendations for future research. Figure 4 shows a schematic description of the dissertation's outline.

Figure 4

Dissertation Outline



CHAPTER II

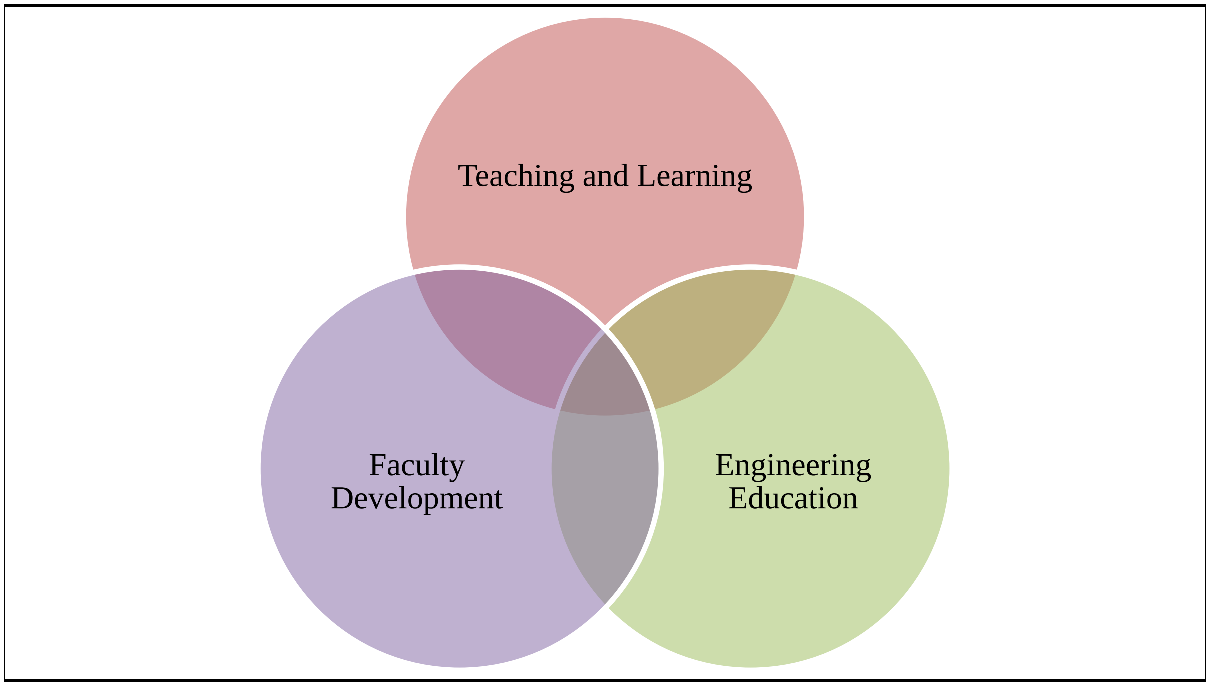
LITERATURE REVIEW

Three seminal bodies of knowledge provide the study foundation aimed at preparing and supporting faculty transition pedagogical paradigm into one that engages and cultivates students in an active learning environment. The contributing seminal bodies of knowledge are: instructional theory, including teaching and learning; engineering education; and faculty development. All three areas played a salient, foundational role in the ALEP's intentional development, design, and implementation. Figure 5 shows a schematic description of these three contributing bodies of knowledge.

Though each of these bodies of knowledge is robust on its own, they are all inextricably related within the study's context. The ALEP's grounding is in the complex intersectionality of all three bodies. Instructional theory, including teaching and learning, plays a salient role in the development of any sound faculty development program, with the inclusion of adult learning theory. Engineering education marries together a solid foundation in engineering content knowledge with a working knowledge of pedagogy to create what Shulman (1986) refers to as pedagogical content knowledge, a "kind of content knowledge…which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (p. 9). Finally, creating a faculty development program meaningful for engineering instructors requires an understanding of both the disciplinary context and an appreciation for its epistemology and how that translates to faculty teaching and student learning.

Figure 5

Contributing Bodies of Knowledge



Teaching and Learning

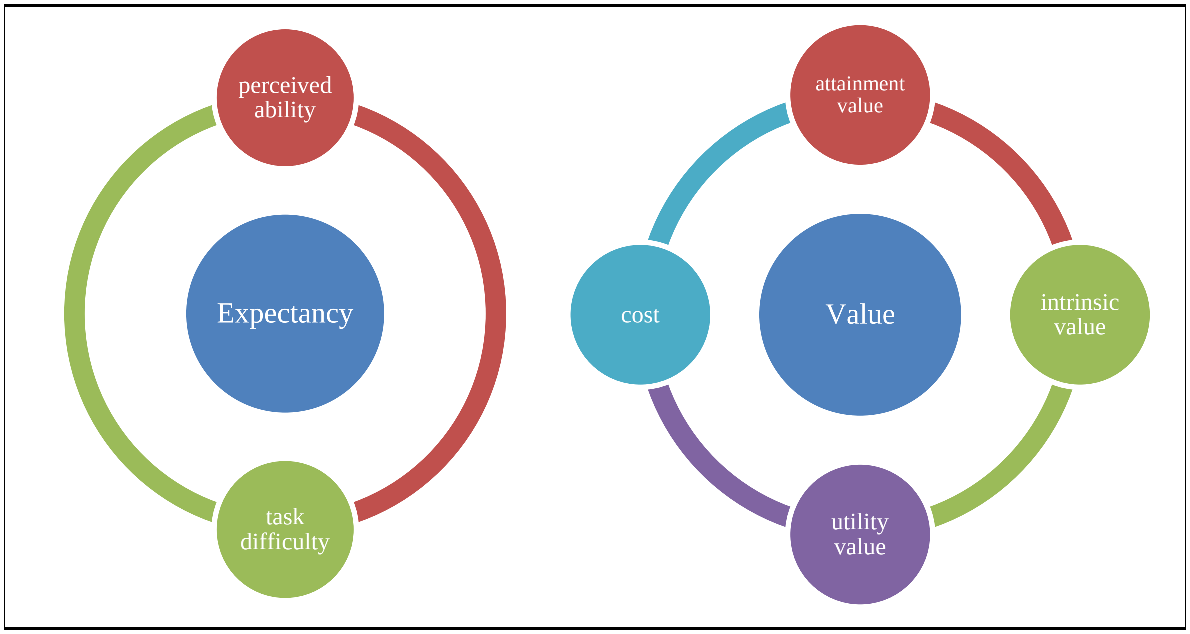
Cognitive psychology is catalyzing change in academia’s instructor role. Research is generating more and more evidence that novice learners require an active environment, rich in multiple and varied representations of material, where the learner can interact with the content in order to construct meaning and make connections (Ambrose et al., 2010; Bransford et al., 1999; Piaget, 1926; Vygotsky, 1978). This research also contributes to engineering education as instructors and programs look to include more evidence-based teaching strategies into their courses. In their seminal work, How People Learn, Bransford et al. (1999) provide three key research findings related to how people learn, which in turn influences how instructors should teach. The first key finding emphasizes the need to tap into and engage students’ prior knowledge while teaching new content, allowing for students’ pattern seeking brains to connect the new content to their existing prior knowledge. The second key finding is the importance of an instructional framework promoting students’ competency building by aiding them in developing and organizing the content being learned. The third key finding looks at metacognition’s role in helping students take charge of and regulate their own learning.

In their book How Learning Works, Ambrose et al. (2010) outline seven research-based principles instructors should consider when informing their approach to teaching. These align and support Bransford et al. (1999) key findings. Their seven principles discuss the role student’s prior knowledge, knowledge organization, motivation, and developmental level play in considering how to approach instruction. They also emphasize the importance of classrooms providing students the opportunity to practice, receive feedback, and self-direct their learning. As an instructor considers their approach to teaching, anchoring instructional decisions to what we know about how learning works is vital to creating a learner-centered environment. Tapping into student’s prior knowledge allows for new content to be connected to existing schema. Helping students organize new information allow from the novice learner to “see” how content fits together. Being transparent about content’s utility and relevancy plays into student’s motivation and willingness to dig in and learn. Knowing at what developmental level students are entering at allows for the appropriate scaffolding of content. Providing a classroom environment where students can practice and be provided timely and relevant feedback helps to ensure learning takes place. Finally, using an assortment of low-stakes, formative assessment allows for students to take a more active, self-directed role in their own learning, shifting the learning responsibility to the learner while providing them an awareness of where to target their efforts.

Student motivation research is another body of knowledge contributing recommendations for improving the state of engineering education. Expectancy value theory provides engineering instructors an insight into what drives students and how an instructor's words, actions, or course experiences can promote or extinguish an individual's motivation. Expectancy value theory explains that an individual's choices are guided by the interaction between expectancy, a person's beliefs about how well he or she thinks they will do on a given task or in a given situation, and the anticipated value associated with the action (Wigfield & Eccles, 2000). Figure 6 shows both expectancy's and value's contributing factors. The part of the figure on the left depicts expectancy, which is made up of two factors that influence behavior: a learner's perceived ability and his or her perception of the task's difficulty. A learner who perceives he or she can accomplish a task at the difficulty level presented will be more motivated to take on the task then if he or she perceives it as too hard or that they lack the required ability to take it on successfully. It is the instructor's job to balance these two factors when creating learning opportunities, bringing the right amount of challenge while helping the learner to know they are capable in successfully meeting the challenge. The part of the figure on the right depicts value, which is made up of four factors that influence behavior: attainment value or importance, intrinsic value or personal enjoyment, utility value or usefulness, and cost. A learner is much more motivated to participate in the learning process if he or she realizes the utility or usefulness, as well as the attainment value or importance, obtained from participation. As a learner, knowing the usefulness and importance of what he or she is participating in and how it serves a future purpose can boost motivation from the start. Also, a learner is much more motivated to participate in the learning process if it is engaging and brings personal fulfillment, helping to build intrinsic value. Finally, a learner is much more motivated to participate in the learning process when the personal cost and anticipated participation effort is low.

Figure 6

Expectancy Value Theory - Expectancy's and Value's Contributing Factors



When planning instructional activities, experiences, and assessments, it is prudent for an engineering instructor to consider the students' perceived expectancy level and attributed value to determine their level of motivation to participate.

Active learning is an umbrella term used to discuss evidence-based teaching strategies. Educational research study findings continue to highlight students engage more with content and show enhanced learning in classrooms where instructors use active learning techniques (Felder & Brent, 2009; Freeman et al., 2014; Hake, 1998; Lord et al., 2012; Michael, 2006; Weimer, 2013). Lacking formal pedagogical training, engineering instructors potentially default to familiar teaching strategies, mainly a traditional lecture-based approach. Active learning may not be intuitive or comfortable for instructors who, themselves, were likely not exposed to such approaches in their educational background. To aid in conceptual understanding of evidence-based teaching strategies, the ALEP provides participants with the following three STEM-focused active learning definitions. Hake (1998), a physicist and the father of interactive engagement, defined it as “those [methods] designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities” (p. 2). It is Hake’s work the ALEP anchored its deliberately broad definition of active learning to as a means to provide instructors with a relatively simple and straight-forward instructional goal – providing students with meaningful, purposeful, minds-on learning activities in the classroom. Prince (2004), a chemical engineer and engineering education researcher, generally defined active learning “as any instructional method that engages students in the learning process” (p. 1). Felder and Brent (2016), seminal researchers in engineering education, defined active learning as “anything course-related that all students in a class session are called upon to do other than simply watching a lecture and taking notes” (p. 113). Active learning requires students to participate in meaningful, purposeful, minds-on learning activities in the classroom. This definition is deliberately broad to help participants grasp that active learning is a broad category of evidence-based teaching strategies that aim to get students actively engaged during class. Researchers have also found that student learning shows an appreciable measure of improvement when assessed using concept inventories even when students reported on surveys they had not learned (Reimer et. al 2016). A comprehensive meta-analysis by Freeman et al. (2014) provides strong evidence in support for the use and adoption of active learning strategies. Their meta-analysis across 225 studies included that students in traditional lecture courses were 1.5 times more likely to fail than those in active learning courses. A one-page resource unpacks active learning, its implications for student learning, and basic steps for getting started using active learning in the classroom (see Appendix A).

Engineering Education

Engineering education has a long and well-researched history; however, recent declines in the number of undergraduate students entering and matriculating through to graduation has commanded the attention of the engineering education community (Felder et al., 1998; Seymour & Hewitt, 1997). Engineering, as is the case with many science, technology, and mathematics (STEM) disciplines, concepts grow in complexity and abstractness. Fundamental engineering instruction typically supports learning with concrete conceptual representations. As students' progress through a program and cognitively mature, instruction is scaffolded from concrete to more abstract conceptual representations, which require the learner to rely more on his/her mental models and conceptual understanding (Piaget, 1952). As concepts become more abstract, the cognitive load increases and becomes more mentally taxing for the learner. Traditional teaching strategies, like lecture, provide little cognitive support or relief for a learner struggling to keep up with the increasing cognitive demand. On the other hand, non-traditional methods assist learners in making more abstract concepts explicit, thus allowing for deeper learning to occur. This helps students build and transition learning from the concrete to the abstract. Pedagogy, an instructor's teaching strategies used in the classroom, has been identified as a leading factor in students' lack of persistence in engineering (Felder et al., 1998; Seymour & Hewitt, 1997).

To help counter the declining number of students entering and persisting in engineering education, James Duderstadt (1999), former University of Michigan President and professor of nuclear engineering, provides a rousing call to action given to engineering instructors and engineering program developers. He states, "It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments" (p. 7). This call to action has ignited an engineering education reformation where instructors use their engineering mindsets to transition from knowledge transmitters to designers of knowledge creation, learner-centered instruction. Engineering education is ripe for a cognitive apprenticeship model where instructors, the disciplinary experts, make the learning explicit for students, who learn as apprentices through observation, imitation, and modeling (Collins et al., 1987). Classrooms become learning communities with instruction transitioning from transactional or transmission sites to knowledge sharing and knowledge creation communities. Brown (1992) calls for classrooms to undergo a design experiment, in which instructors create a working environment or a "work site", anchored in learning theory, where students "perform assigned tasks under the management of teachers into communities of learning" (p. 141). However, many engineering instructors are not trained in such non-traditional methodologies. As a result, engineering colleges and departments have made efforts to assist instructors in developing such pedagogical capabilities and efficacy.

Engineering education is a diverse and multidimensional epistemology. It is a mixture of intellect, practicality, creativity, and ethics. As described by Shulman (2005), engineering education is

> a lovely juxtaposition between the formal requirements entailed in learning math and science and the creative challenges that accompany “messing with the world.” ...that all that knowledge and creativity, collaboration and communication, must be accomplished within a matrix of social and environmental responsibility. (p. 11)

The combination of Duderstadt’s call for action with Shulman’s engineering education description produces a vision for the necessary engineering education transformation. This degree of change requires both individual instructor and institutional level attention in which engineering education is overhauled to reflect 21st century learning practices, as well as 21st century students.

Engineering education reformation should include both curricular and pedagogical considerations – how should the next generation of engineers be prepared and developed to handle the ever-changing societal and global demands? Engineering, regardless of the specific discipline, demands an interdisciplinary approach, rooted in complex and authentic problem solving, to equip students with what Dewey (1929) calls “intellectual instrumentalities”. Kliebard (1993) offers a pragmatic explanation of Dewey’s intellectual instrumentalities concept, “They exist not to provide rules for how to conduct oneself under particular circumstances but as instrumentalities for helping sentient human beings in real, rather than contrived, settings to conduct their own inquiries into what they do”

(Kliebard, 1993, p. 300). Shulman’s explanation of engineering education as: (a) “a lovely juxtaposition”, (b) anchored in the hard sciences, as well as creativity and ethics, which (c) immerses engineering students in the art of engineering design, allows for Dewey’s intellectual instrumentalities to take root and grow. Their development allows engineers to easily traverse and apply their interdisciplinary knowledge base. Rather than prescribing engineering students a rote, discrete set of knowledge and skills, provide them with authentic opportunities to practice, develop, and sharpen their intellectual instrumentalities. This curricular framework equips engineers with the cognitive dexterity to achieve what Dewey and Kliebard called for - “to conduct their own inquiries into what they do”.

Engineering as a discipline is rooted in a foundation of both engineering theory and design practice. Engineers are called to be proficient in the content of their discipline, literate in both disciplinary knowledge and the design process, in order to produce, create, and develop. To prepare T-shaped engineers (Rogers & Freuler, 2015), who not only have a solid disciplinary content foundation, but also have a solid set of engineering-specific transferable skills, is not trivial. It is advantageous for engineering educators to be competent and confident in implementing teaching strategies that allow students to begin building both the content and skills necessary for the profession. Since the inception of the university, lecture has been the predominant pedagogical practice used to deliver course content. The new onset of cognitive research has challenged engineering educator’s reliance on lecture’s role as the responsible mode of instruction. Factor in the declining number of students entering and matriculating through to graduation in undergraduate STEM programs, the need to address the merit of current pedagogical practices used in engineering education becomes salient. Do programs continue with the status quo, teaching strategies founded on tradition, or do they promote teaching strategies founded on evidence that engage students in their learning.

Beichner et al. (1999), in their work integrating math, physics, engineering, and chemistry at North Carolina State University, offer an integrated instructional approach for engineering programs to incorporate. The researchers set out to measure “the impact of the highly collaborative, technology-rich, activity-based learning environment on a variety of conceptual and problem-solving assessments and attitude measures” (p. 1). The researchers found that the integrated curriculum had a significant positive impact on several student measures such as student performance, satisfaction, confidence rates, retention, as well as success rates. The engineering courses, in the spirit of Dewey’s intellectual instrumentalities, intentionally focused on teaching transferable skills such as how to work in teams, effective writing and speaking communication skills, and time management.

Other STEM-specific studies offer evidence-based findings that hold recommendations for improving the state of engineering education. Engineering educators Smith, Sheppard, Johnson, and Johnson (2005) bring the student engagement conversation to the engineering community in their manuscript on pedagogies of engagement. These authors promote providing the engineering education community with a broad overview of active and cooperative pedagogies of engagement, anchored with multiple engineering specific examples, to help facilitate more knowledge creation environments in engineering courses and programs. Freeman et al. (2014) provide a seminal piece on the impact active learning strategies have on student performance in an extensive meta-analysis of 225 studies comparing student performance in undergraduate STEM courses using traditional lecture vs. active learning. This group of researchers found that students whose instructors relied on traditional lecture methods only were 1.5 times more likely to fail than students whose instructors used active learning techniques (Freeman et al., 2014). To help further explain the benefits of using active learning in the classroom, Freeman et al. (2014) declares:

> If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial. (p. 8413)

This statement provides an analogy that is striking in the saliency of their findings, helping to cement the intentionality of the study's findings and their implications for the classroom.

In his National Academies National Research Council Board of Science Education status report, Fairweather (2008) emphasized the need for institutional change as a means of driving instructor adoption of evidence-based teaching strategies:

> …enhancing the value of teaching in STEM fields requires much more than empirical evidence of instructional effectiveness. It requires active intervention by academic leaders at the departmental, college, and institutional level. It requires efforts to encourage a culture within academic programs that values teaching. Whether through intervention in promotion and tenure decisions, salary structures, or provision of additional resources, active engagement by institutional leaders is a prerequisite to teaching reform efforts to succeed. In the end, instructor members take their cues about what their institutions value by looking at salary and promotion and tenure decisions rather than the rhetoric about or evidence in

> support of good teaching. (p. 24)

Without a concerted effort to instill institutional change, efforts to implement any sort of pedagogical transformation would prove fruitless.

In summary, the engineering education literature strongly suggests instructors aim to create a more dynamic classroom environment, where learners engage in cognitive apprenticeship work sites. This calls for the learning environment to transform from one of knowledge transfer to knowledge creation where students transition from being engineering students to pre-professional engineers.

Faculty Development

Faculty development is a form of adult education and, therefore, to be effective, requires a spectrum of multiple and varied formats to suit participants needs, schedules, and engagement level. Possible formats include formal, scheduled workshops or professional conferences; non-formal lunch groups discussing course issues; or informal casual teaching observations while walking by an opened-door classroom. Many institutionally embedded centers for teaching and learning focus on formal or non-formal learning to meet instructor’s needs. Furthermore, research-intensive institutions recruit from around the world, making them a true microcosm for adult learning. Merriam, Caffarella, and Baumgartner (2007) refer to this as a “learning society” across campus (p. 25). Faculty development in a “learning society” proves difficult in that instructors are usually the ones doing the teaching, not the learning. Where students enter the “learning society” as a novice ready to learn, an instructor enters as an expert ready to teach. This creates a strong need for educational developers to be cognizant and diligent in their understanding of adult learning theories and practices, as they aid instructors in traversing roles between teacher and learner.

When working in faculty development, it is prudent educational developers understand the motivation that drives instructor participation. Wlodkowski (1981), in his Time Continuum Model of Motivation, identified six major factors taken from psychological research that impact adult's motivation to learn: attitude, need, stimulation, affect, competence, and reinforcement.

- Attitude encompasses one's thoughts, feelings, emotions, and experiences that predispose them to react approvingly or adversely to a situation. Need is the internal catalyst driving one's actions.
- Stimulation is a variation in our external surroundings that causes us to react.
- Affect is one's emotional powerhouse – feelings, passions, and worries.
- Competence "is the concept or major motivation factor that describes our innate desire to take the initiative and effectively act upon our environment rather than remaining passive and allowing the environment to control and determine our behavior" (Wlodkowski, 1981, p. 55).
- Reinforcement, a term often associated with Skinner and his use of "operant conditioning", is anything that strengthens or increases the likelihood of a response.

Wlodowski stressed the integral role motivation planning has in any faculty development preparation. He proposed the Time Continuum Model of Motivation that strategically places each of the six adult learning motivation factors into the three main segments of an event – beginning, during, and ending – in order to maximize the influence of each factor. Attitudes and needs should be addressed in the beginning of the event, as the adult learner commences to take part in the learning. Stimulation and affect are to be addressed during the event to motivate the adult learner as they sustain the event's duration. Competence and reinforcement should be addressed at the event's ending as the adult learner is bringing the learning to a close. When arranged in this manner, the Time Continuum Model of Motivation allows, "for each general motivation factor so that a continuous and interactive motivational dynamic is organized for maximum effective teaching" (Wlodowski, 1981, p. 105). This is not just for maximum effective teaching, but it is also for maximum effective learning where an adult learner's motivation is respectfully considered and factored into the learning event's organization.

McClusky's Theory of Margin (1970) is another theory contributing to the understanding of instructor's motivation to participate in faculty development, which focuses more on an adult's personal life situation. The theory looks at the ratio between the "load" of life, which dissipates one's energy, and the "power" of life, which allows one to deal with the load. McClusky explains for learning to take place, the learner needs some portion of power available for use in the learning process. The Theory of Margin requires adult learners to adequately manage the multiple demands on their time to afford remaining power for learning. This theory is a way for educational developers to consider an instructor's learning potential by considering his or her existing responsibility load versus existing resource pool and motivation.

Malcolm Knowles (1968) proposed six assumptions pertaining to adult learners that, when used to anchor faculty development, strengthen the adults' learning experience.

He labeled his set of assumptions as andragogy, which literally means the art and science of helping adults learn, as contrasted to pedagogy, which means the art and science of helping children learn. These six assumptions provide educational developers specific adult learner insights to take into consideration and validate while planning - an adult's innate sense of utility, self-concept, experience, readiness to learn depends on need, task-oriented focus, and internal motivation (Knowles, 1980; Merriam et al., 2007). Androgy's assumption one pertains to an adult's need to know. While working with adult learners, there should be a deliberate and clear explanation of the delivered content's rationale, relevance, and utility. The educational developer should clearly convey to the adult learner the WHY piece of both the benefits of knowing and the risks of not knowing the content being delivered. This also includes an advanced organizer to explain how the learning will occur, what the learning will be, and why it is important. The second assumption deals with self-concept and the fact that adults are responsible for making their own decisions. This encourages educational developers to harness adult's innate need to be self-directed and afford for self-management of learning where one can take ownership of his/her own learning. Andragogy's third assumption highlights the vast amount and diverse experiences adults bring to the learning environment. The learning should allow adults to draw on their experience, as that experience is closely tied to their identity and prior knowledge base. The learning should also associate new content with existing knowledge, as well as take place in an active, constructive, and collaborative environment. The fourth assumption deals with the adult learner's readiness or need to learn. Adults tend to seek out learning opportunities when there is a driving need to perform more efficiently in a life arena, thus ensuring that learning needs are timely, relevant, and focused on practical and immediate application. Andragogy's fifth assumption focuses on the learning's orientation. It should be relevant, task-oriented, and follow Kolb's (1984) Experiential Learning cycle – concrete experience, reflective observation, abstract conceptualization, and active experimentation. Knowles' sixth, and final, andragogical assumption parallels Wlodowski's Model of Motivation as it looks at the adult learner's motivation, internal or external drivers, for learning.

Another adult learning theory that assists educational developers in creating meaningful faculty development is Jarvis' (2006) Model of the Learning Process. Jarvis explains learning as

> the combination of processes throughout a lifetime whereby the whole person… experiences social situations, the perceived content of which is then transformed cognitively, emotively or practically (or through any combination) and integrated into the individual person's biography resulting in a continually changing (or more experienced) person. (p. 134)

Merriam et al. (2007) elaborate on Jarvis' Model of the Learning Process to explain that the learning process starts with a disjuncture between one's whole self and his or her lived experience. The disjuncture, similar to Piaget's (1952) cognitive disequilibrium, creates a situation that the person is cognitively, emotionally, or practically unprepared to handle. The disjuncture between a person's self and his or her lived experience leads to learning that involves a change in his or her emotions, thoughts, or actions. Learning happens in context. By experiencing a disjuncture, the learner is not currently prepared to handle (disequilibrium), he or she pursues a new, appropriate response. The new learned response restores equilibrium and better equips the learner to handle future situations. Jarvis's

Model of the Learning Process helps educational developers understand the salient role a disjuncture plays the adult learning process.

Kolb (1984) provides the educational developer with further understanding of adult learning. He defines learning as, “the process whereby knowledge is created through the transformation of experience” (p. 38). In his Experiential Learning Model, Kolb depicts learning as a cyclical process consisting of four stages the adult traverses for learning to occur. The four stages are: 1) concrete experience, 2) reflective observation, 3) abstract conceptualization, and 4) active experimentation. In Kolb’s stage one, concrete experience, the learner actively participates in an experience. Stage two requires the learner to consciously observe and reflect on the learning experience at hand in order to transition into stage three, where the learner attempts to form abstract concepts based on his or her reflective observation. Stage four sees the learner plan and test his or her newly formed concepts in a new situation. Kolb’s Experiential Learning Model provides an educational developer with an iterative process that brings about learning through intentional observation and reflection on the experience at hand. Learning and the creation of new knowledge are born out of the transformation of experience. Reflection bridges the learner’s practical experience and theoretical conceptualization (Kohonen, 2007).

All the adult learning theories reviewed help educational developers recognize that faculty development in higher education does not happen in isolation. It can involve single individuals, diverse groups of individuals, discipline-specific departments, and even whole colleges or programs. The development efforts can be self-initiated by the individual instructor or top-down mandated to the instructor. Whatever the faculty development dynamic or impetus, effective faculty development, as with any learning endeavor, involves change. “Learning involves change in knowledge, beliefs, behaviors, or attitudes. This change unfolds over time; it is not fleeting, but rather has a lasting impact on how [instructor] think and act” (Ambrose et al., 2010, p. 3).

For faculty development to attain a true lasting change associated with learning, researched-proven change strategies should be used, as not all change strategies are equally effective. Henderson et al. (2011) found in their analytic review of the change literature two commonly used, yet ineffective, change strategies – 1) “best practices” dissemination and 2) “top down” policy-formation - to influence pedagogical change. They explain that what does affect true change are strategies that

> are aligned with or seek to change the beliefs of the individuals involved; involve long-term interventions, lasting at least one semester; require understanding a college or university as a complex system and designing a strategy that is compatible with this system. (p. 1)

For faculty development to be meaningful and achieve long-term change, educational developers need to be cognizant of effective change strategies and work to embed these in development opportunities.

There are numerous higher education resources that share quality academic change models that reinforce faculty development to bring about lasting change (Elrod & Kezar, 2017; Felder & Brent, 2016; Finelli et al., 2014; Fowler et al., 2015; Lattuca & Stark, 2011; Pallas et al., 2017; Wieman, 2017). The faculty development’s nature and purpose drive the particular model used, with each model having its own unique purpose and rationale. Regardless of the model, most serve the larger purpose of improving teaching in U.S. institutions of higher education. Below is a brief overview of four academic change models that reinforce faculty development in some manner.

In order to appeal to a diverse audience of engineering instructors, Finelli et al. (2014) intentionally used multiple and varied faculty development formats: workshop sessions, learning communities, consultations, and peer teaching observations. Each event format can be tailored to a different purpose based on event purpose and setting, as well as instructor needs. Workshops provide time and resources engineering instructors need to carefully discern which pedagogical tool may be more useful for one’s topic, students, and personal teaching style. Learning communities provide a more informal and intimate setting to truly dissect and discuss readings, research, and course issues. One-on-one consultations provide a safe place for targeted dialogue and customized assistance. Peer teaching observations provide effective teaching practices modeled in an engineering classroom. Each faculty development format provided a unique opportunity and varied approach to afford for instructor learning to occur, with the overarching goal being to bring about a lasting change. Topics such as curriculum (intellectual instrumentalities), student motivation (expectancy value theory), cognitive psychology (how learning works), and pedagogies of engagement (active learning) can be discussed, analyzed, questioned, and practiced in an engineering context. Susan Ambrose (2009, cited as Personal Communication in Felder et al., 2011), a prominent faculty development authority who has worked extensively with engineers, explains,

> Too many programs dispense tips and strategies, as opposed to educating instructor members about how learning works…and we do a great disservice when we do this because tips and strategies often do not transfer across contexts. The mission of all of these programs should be to try and bridge the gap between

> what we know about learning and how we design and teach courses.

Finelli et al.'s instructor action plan approach assists instructors bridge the research-to-practice gap to transform their pedagogical practice, an example demonstrating what Froyd et al.'s (2017) describe as using propagation methods to promote the implementation of evidence-based teaching strategies.

In his book - *Improving how universities teach science: Lessons from the science education initiative,* Wieman's (2017) explains his work to change both science teaching and the organizational context in which the science teaching takes place. Wieman's Science Education Initiative refers to the largest agents of change as Science Education Specialists (SESs). SESs have both content expertise, as well as pedagogical content knowledge including relevant discipline-specific teaching methods and epistemological understandings. Faculty development was the job of the SESs who collaborated with instructor either individually or in small groups, to bring about course transformation. SESs worked with instructors to help advance their knowledge of teaching and learning, as well as provide them with support as they integrated evidence-based instructional methods into their existing courses.

Elrod and Kezar (2017) developed an eight-stage institutional change model that focuses on increasing student success in STEM disciplines. The model utilizes institutional level reform over single course or individual program level reform, where "cross-functional teams" work collaboratively with the support of varied levels of leadership. The model is based on organizational learning processes. The authors explain that, "Within this approach to change, information gathering and data analysis play a central role in helping individuals to identify directions and appropriate interventions for making strategic progress" (Elrod & Kezar, 2017, p. 28). Faculty development components include data analysis, reflection, dialogue, and collaboration in "non-hierarchical teams" to develop and implement a shared vision and change plan, which addresses the local context.

Regardless of the change model used, one of the final steps in the process is to report out to the larger field or institutional context the concluded project's findings in hopes of innovation adoption by others. This dissemination process' purpose is for "good ideas, supported by convincing evidence of efficacy, will spread "naturally" – that, on learning about the success of particular initiatives, others will become convinced enough to try them" (Seymour, 2002, p. 92). Based on the dissemination paradigm, one would expect to find evidence-based instructional practices being used in all classrooms across the entire landscape of U.S. institutions of higher education. But, that is not often the case. Froyd et al. (2017) offer an alternative solution to the dissemination paradigm – the propagation paradigm. In the propagation paradigm, change agents "engage with adopters early and often to understand their instructional systems and interactively develop a strong product adaptable to specific contexts" (p. 35). Propagation ensures that an innovation is contextually practical, that it fits, and is highly effective in meeting the adopter's needs.

A review of the literature suggests that faculty development would be more impactful using propagation methods instead of dissemination. Instead of disseminating evidence and best practices, educational developers are best served by using more of a propagation approach, in which the needs of the individual or organization drive the change. This is not to say that educational developers always start with a blank slate;

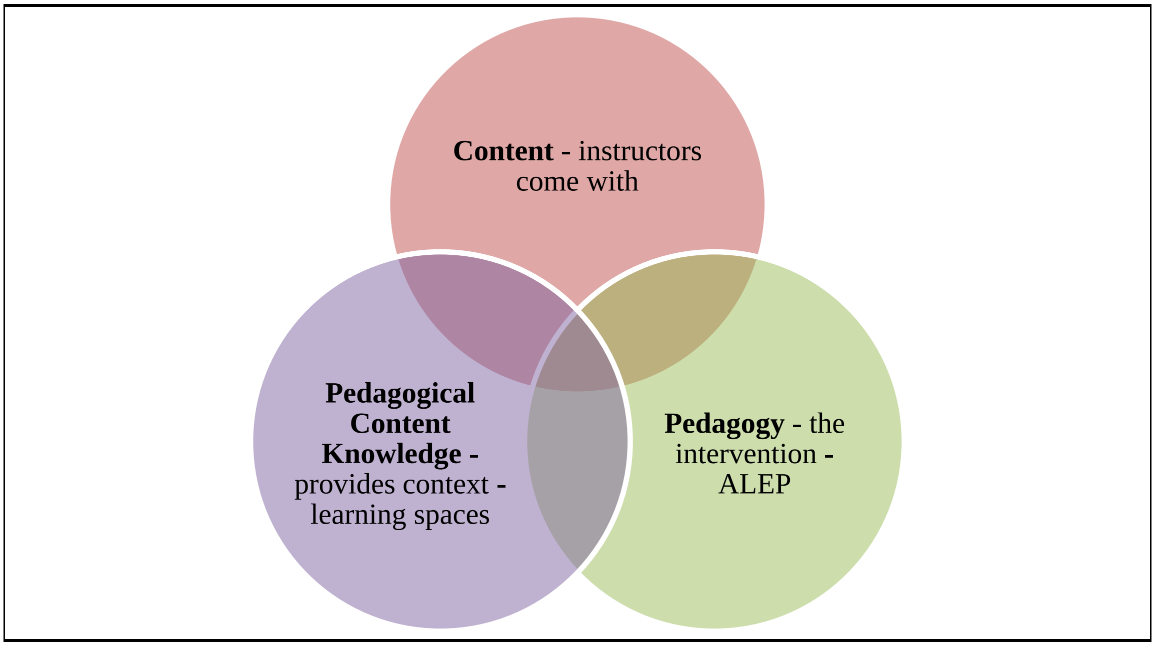
their knowledge of research-proven, evidence-based methods, strategies, models and plans is invaluable. This is also not to say that educational developers work with individuals or organizations to customize and adapt methods and strategies to fit the specific context in which change is necessary. Models and plans for change provide a good starting point, but an educational developer needs to remember to be flexible and not let procedure overrun process. Propagation methods help educational developers prepare instructors, build community, promote evidence-based teaching, and create instructor leaders as they help to bring about individual and/or organizational change (Morrone et al., 2017).

The ALEP's Foundation – Engineering Faculty Development

Memory plays a key component in learning. As a novice, the learner works to build retrieval fluency, our ability to efficiently pull bits of information stored in long term memory to mind for use (Benjamin & Bjork, 1996). Associational fluency is the "ability to rapidly produce a series of original or useful ideas related to a particular concept…quality rather than quantity of production is emphasized" (McGrew, 2013, para. 3). The ALEP aimed to assist engineering instructors build associational fluency between three salient instructional areas: (a) content, which instructors come with; (b) pedagogy, an instructor's teaching strategies; and (c) pedagogical content knowledge, teaching context – content specific teaching strategies. Shulman (1986) refers to pedagogical content knowledge as the instructor transforming subject-matter knowledge for the purposes of facilitating student learning. Figure 7 shows the three instructor associational fluency areas the ALEP seeks to help engineering instructors confidently migrate between as they plan learning experiences for their students. The pedagogical component serves as this study's intervention – the Active Learning in Engineering Program (ALEP). The program aims to build engineering instructor's ability and efficacy to traverse seamlessly through these three areas. As instructors begin to assimilate evidence-based teaching strategies into their teaching, it was the ALEP's goal to equip them with a solid foundation in pedagogy and pedagogical content knowledge to complement their existing content knowledge. Within the intervention, the ALEP focuses on engineering examples, disciplinary specific problems, and context to help promote instructor's associational fluency, thus allowing them to merge and enhance their content instruction, active learning strategies, and existing engineering pedagogical knowledge.

Figure 7

Instructor Associational Fluency Areas



The adoption of an innovation theory plays a salient role in helping to understand an individual instructor’s ease and rate at which each he or she transitions from theory to application. In this study, the innovation was incorporating evidence-based active learning teaching strategies. The adoption of an innovation theory provides the ALEP with a three-layer framework to assist faculty in transitioning from theory to application. The first layer is to provide instructors with a solid STEM-focused theoretical foundation promoting and supporting the use of evidence-based teaching strategies, particularly active learning strategies, in higher education. The second layer is to provide instructors with a solid pedagogical content knowledge foundation to work from as they begin to discern which pedagogical tool may be more useful for one’s topic, students, and personal teaching style. The third layer is to provide faculty with time and resources to assist them in planning and implementing evidence-based teaching strategies into their existing pedagogical paradigm.

The ALEP helped to develop and strengthen engineering instructor’s knowledge base of teaching, which encapsulates all an instructor needs to know and be able to do, to effectively teach for meaningful student learning to occur more fully. An instructor’s knowledge base of teaching includes formal learned knowledge, such as that shared in the ALEP, as well as personal practical knowledge (Connelly & Clandinin, 1988). It includes discipline-specific content knowledge, general pedagogical knowledge, as well as Shulman’s (1986) pedagogical content knowledge. It also includes local crafted knowledge, as well as global research knowledge (Fenstermacher, 1994). The knowledge base of teaching is multidimensional, including knowledge of learning, knowledge of the learner, and knowledge of the learning environment. Verloop et al. (2001) explain the vastness of the knowledge base of teaching:

> …the knowledge base of teaching will be defined as all professional-related insights that are potentially relevant to the teacher's activities. The insights can, for example, pertain to formal theories (such as the classical theories from research), but can also pertain to information about the knowledge and beliefs of expert teachers which has emerged from more recent research. (p. 443)

An epistemological transformation takes place within a person as the many facets meld and gel to become one integrated, synthesized mindset known as the instructor's knowledge base of teaching.

The emphasis of this research is on the knowledge base of teaching for engineering instructors in higher education, which is the target population for this dissertation research. Across colleges of engineering, the primary focus and responsibility for many instructors is research. It is not uncommon for an engineering instructor to be hired solely for based on research record and agenda, with little regard paid to teaching ability. However, there is a paradigm shift taking place across U.S. campuses (Barr & Tagg, 1995). Where once institutions were very traditional, didactic, instruction-heavy learning environments, they are slowly being replaced with learning environments focused more on learning and learner-centered instructional methods.

The knowledge base of teaching in post-secondary engineering is influenced by many different contributing stakeholders. Each engineering disciplinary program aligns with an ABET, engineering's governing body, set of accreditation criteria, as well as seven engineering student outcomes. The seven engineering student outcomes are (ABET, 2021, Criterion 3. section):

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

These general engineering student outcomes serve as global, overarching mandated set of content and skills to be taught across all engineering programs regardless the program area. In addition to ABET, each individual institution sets forth university-level student learning outcomes, which then serve as additional mandated content and skills to be taught. The instructor, as an expert in their field, also brings content and skills they feel should be taught. Each of the aforementioned stakeholders bring to engineering’s knowledge base of teaching content and skills to be taught but leaves autonomously to the individual instructor the “how” piece, i.e., the pedagogical part of the knowledge base. The “how” piece is up to the engineering instructor’s discretion, many of whom are not trained educators and therefore have a gap in his or her knowledge base.

The ALEP’s foundation carefully pieced together the salient instructional pieces – content, pedagogy, and pedagogical content knowledge - in a unified approach, supported by the literature, to achieve its goal of preparing and supporting engineering instructor’s transition to a more learner-centered pedagogical paradigm by incorporating active learning teaching strategies. The project management team strove to create an engineering-focused environment, where the ALEP instructor participants felt comfortable and supported to explore and engage with various active learning strategies being shared to choose one or two to try in his or her instruction. Deliberate time and attention were given to providing the instructor participants with time and resources to develop an implementation plan, as well as follow-up dialogue and sharing of how the implementation went. This was not haphazard in design, but rooted in literature and previous faculty development experience.

CHAPTER III

METHODOLOGY AND ANALYSIS

Introduction

This study was a three-way partnership between Texas A&M's CoE, CTE, and ITS. Engineering has been an area of study at Texas A&M since the University's inception in 1876. It is housed in what is now the largest college on the flagship campus in College Station, with more than 20,000 students and 700 faculty members. The CoE currently offers 22 graduate and undergraduate degrees housed in 15 departments (Texas A&M University Engineering – Facts and Figures, 2019).

In response to a 2012 national call for more engineering graduates, the CoE, in 2013, unveiled its 25x25 initiative (President's Council of Advisors on Science and Technology [PCAST], 2012). The 25x25 initiative lays out plans to enhance engineering students' educational experiences while at Texas A&M and provide new opportunities for student success. The initiative's aim is an increase in retention rates as a means of reaching 25,000 engineering students by 2025. Key initiative objectives are to transform the student experience, increase access to engineering education, and provide affordable engineering education. To help accomplish these objectives, the CoE sought to modernize their facilities as a means of supporting pedagogical change, which included innovatively designed learning spaces in the new Zachry. The updated learning spaces catalyzed the need to provide instructors with faculty development to assist their pedagogical transition into the newly renovated Zachry spaces, encouraging them to incorporate more evidence-based teaching strategies as a way of moving towards the College's 25x25 goals.

Research Design

This study used a quasi-experimental representative design to determine the ALEP's effectiveness in preparing engineering instructors' transition to a more learner-centered pedagogical paradigm by incorporating evidence-based teaching strategies (Campbell & Stanley, 1963; Snow, 1974). It took place in the context, in the environment, in which the natural phenomena happen affording the researcher the opportunity to use a representative design. It was a cross-section study, collecting data from the sample at snapshots in time over Spring 2018 through Fall 2019 (Fraenkel et al., 2015). Because instructor participants self-selected to participate in the ALEP, random assignment was not possible. The research questions guiding this study were:

1. Are there differences between the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors? Are there changes within the classroom teaching strategies utilized by ALEP instructor participants after Program participation?
2. Does an ALEP instructor participant's TPI score relate to his/her COPUS observation score?
3. Does the ALEP instructor participant's post-ALEP COPUS observation score relate to his/her ALEP participation intensity or his or her pre-ALEP COPUS observation score?

In the consideration for this study's methodology, each research question required a varied methodological approach with different subjects, different instrumentation, and different procedures. Therefore, the methodological approach to investigating each research question will be detailed below. Table 1 details this study's research design by research question.

Table 1

Study's Research Design by Research Question

Research Question	**Design**
Research Question #1	Between Two-Group Pretest-Posttest Design O O - - - - - - - - - O X O Within One-Group Pretest-Posttest Design O X O
Research Question #2	One-group - congruency test - Is what faculty self-report congruent with what was observed in the classroom?
Research Question #3	One group - associational test

The study was framed in a quantitative research perspective (Creswell, 2009). Quantitative research designs allow the researcher to objectively test a theory by stating targeted hypotheses and then collecting data to refute or support the stated hypotheses. Statistical procedures were employed to analyze the collected data as a means of examining relationships among variables. Quantitative research methods aligned with the nature of the data collected from both instruments, the TPI and the COPUS, were used for analysis. The TPI and the COPUS allow for inferences to be made about the sample's teaching practices, for timely data analysis, for ease in large sample administration, and are valid and reliable open-source materials. This study included research during the Spring 2018, Fall 2018, and Fall 2019 semesters.

Participants

This study's sample was a cross-sectional, purposive, convenience sample of an already intact group of more than 700 engineering instructors from across the College's 15 engineering departments who self-selected to participate in the ALEP (Shadish et al., 2002). The study's research participant inclusion criteria consisted of men and women participating in ALEP, who were 18 years of age or older, and were currently an instructor of record at Texas A&M for at least one engineering course a semester in both Spring and Fall 2018. Exclusion criterion consisted of non-ALEP instructors and those who were not an instructor of record at Texas A&M for at least one engineering course a semester in both or either Spring or Fall 2018. Those who met this inclusion criteria became the researcher's treatment group. This study also included a control group made up of non-ALEP engineering instructors who also taught at least one engineering course in either or both the Spring 2018 and Fall 2018 semesters. The control group was based on the course taught, mirroring the ALEP instructor participant treatment group as much as possible in five areas: (a) engineering department taught, (b) course number or course number level taught, (c) course delivery format and modality taught, (d) class size taught, and (e) type of space taught.

Approximately 100 engineering instructors were either nominated by his/her department head/program director or self-selected to be part of the inaugural group of instructors to teach in the newly renovated Zachry and participate in the Spring 2018 ALEP. Research participation was optional; participants could opt out of the study at any time. Study participation did not affect their employment or participation in the ALEP. The alternative was not to participate. The ALEP instructor participants who chose to participate in the Spring 2018 ALEP and who met the inclusion criteria became the researcher's initial ALEP treatment group sample, a total of 32 participants. The Spring 2018 control group, made up of the non-ALEP engineering instructors, contained 28 comparison participants. The Fall 2018 control group, made up of the non-ALEP engineering instructors, contained 29 comparison participants. Nine non-ALEP engineering instructors were common to both the Spring 2018 and Fall 2018 control groups. Table 2 details this study's participant demographics.

Table 2

Overall Study Participant Demographics

	Overall (*n* = 80)		Control Group (*n* = 48)		Treatment Group (*n* = 32)	
	n	%	*n*	%	*n*	%
Treatment						
Control	48	60.0				
Treatment	32	40.0				
Gender						
Female	12	15.0	3	6.3	9	28.1
Male	68	85.0	45	93.8	23	71.9
Tenure						
Non-Tenure Track	35	43.8	19	39.6	16	50.0
Tenure Track	45	56.3	29	60.4	16	50.0
Industry Experience (*n* = 71)						
No	13	16.3	8	16.7	5	15.6
Yes	58	72.5	35	72.9	23	71.9
Industry Experience (Average Years)	10.5 (*n* = 71)		10.8 (*n* = 43)		10.1 (*n* = 28)	
Teaching Experience (Average Years)	14.6 (*n* = 63)		15.9 (*n* = 43)		11.68 (*n* = 20)	
CoE Departments Represented	15		12		8	

Confidentiality

The study’s records are kept private and confidential. Research participants can be identified; however, information gathered is protected. No identifiers linking participants to the study will be included in any sort of published report. Since the researcher is interested in the engineering instructor’s teaching practices and their change-over-time, it is necessary to be able to link each instructor’s pre- and post-measures.

Risks and Benefits

Study participation involved no greater risk than what a participant would come across in everyday life. The probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. Participants did not receive compensation or direct benefit other than the satisfaction of contributing to this study. The study’s findings will be shared internally and externally to assist in the creation of future faculty development. Externally, the researcher will share results with professional colleagues through conference presentation(s) and/or journal article(s).

Participant Recruitment

To recruit study participants, the researcher emailed a recruitment letter, including the researcher’s contact information should potential participants request further information. The study’s consent document was attached for potential participants to review in advance of being asked to partake in the research and provide consent. Emails were sent directly to individual instructors, or, for group emails, individual instructor email addresses were listed in the blind carbon copy address section. The emailed recruitment letter was addressed generally to "Dear Engineering Instructor" and did not include actual individual instructor names.

Informed Consent

Informed consent took place in one of three ways depending on the research activity. Informed consent took place:

- For the online pre-survey, the potential treatment group participants used their personal computers to read the study overview and complete the consent document included at the beginning of the Qualtrics pre-survey.
- For the TPI, the potential treatment group participants received a paper copy of the study overview and consent document in the classroom, ETB 2026, used to conduct Workshop #1.
- For the classroom observations conducted using the COPUS, the potential treatment and control group participants classroom received a paper copy of the study overview and consent document in their classroom prior to the observation being conducted.

This study was later found to be an exempt study, so informed consent was no longer necessary, though consent had already been collected from both the treatment group and the control group participants.

Intervention and Study Variables

Intervention

This study’s intervention was the ALEP. The ALEP was created, implemented, and managed by a project management team with members from all three Texas A&M partnering units – CoE, CTE, and ITS. The ALEP offered five different faculty development types, for a total of eight individual events, over the course of the Fall 2017, Spring 2018, and Summer 2018 semesters for interested engineering instructors to participate. Each ALEP faculty development type is listed below, including when it is offered:

1. Pre-work – a pre-ALEP Qualtrics questionnaire was offered via the Program's eCampus Organization beginning late Fall 2017 and closed at the start of Workshop #1. Online instructional technology modules (4), also housed in the Program's eCampus Organization, were continuously offered beginning late Fall 2017. The online module titles were:
    a. Teaching within an Active Learning Space
    b. Flipping Your Course Overview
    c. Overview of Instructional Technologies
    d. Overview of Americans with Disability Act & Universal Design
2. Face-to-face workshop sessions (3) – offered in Spring 2018
    a. Workshop 1: Introduction to Active Learning - designing and adopting active learning strategies, managing active learning and practice.
    b. Workshop 2: Implementation of Active Learning – adopting and adapting teaching strategies, course design and practice.
    c. Workshop 3: Share Out of Active Learning course ideas - assessing learning in active learning spaces, looking ahead, and sharing out course ideas
3. Community of Scholars sessions – offered in Spring 2018
    a. Role of the instructor and Managing Active Learning Spaces
    b. Activities & assignments in Active Learning Spaces; Working with groups

4. Technology training clinics – offered Spring and Summer 2018
5. One-on-one in-classroom practice teaching sessions – offered August 2018

The ALEP instructor participants were encouraged to participate in all Program faculty development offerings. The technology training was the only required component for those teaching in the updated Zachry and was offered college wide. The one-on-one in-classroom practice sessions were also offered college-wide to those teaching in the updated Zachry. Some of the control group participants did attend one or both general intervention components – the technology clinics and the one-on-one in-classroom practice teaching sessions. Though they were part of the ALEP faculty development offering, these two did not focus on teaching active learning pedagogy this study was addressing. These two general Program components offered engineering instructors a time to learn more about the specific room technology, as well as practice what they had learned and planned to implement from their ALEP participation.

All ALEP instructor participants received a copy of A Guide to Teaching in the Active Learning Classroom: History, Research, and Practice (Baepler et al., 2016). The book was not a required read, but participants were strongly encouraged to read it in its entirety as it provides a foundational working knowledge for both the ALEP workshops and the Community of Scholar events, as well as for their teaching in the updated Zachry. Also, the book contains useful and relevant information that, for the sake of time, the ALEP couldn’t discuss in-depth or to the level of detail all participants would prefer. The books were distributed to participants at the ALEP November Kickoff event. The Kickoff event was not mandatory for participants but provided an initial community building opportunity for both the participants and the ALEP project management team. Table 3 shows the ALEP schedule, including the Program offerings broken down by semester.

Table 3

Active Learning in Engineering Program Schedule

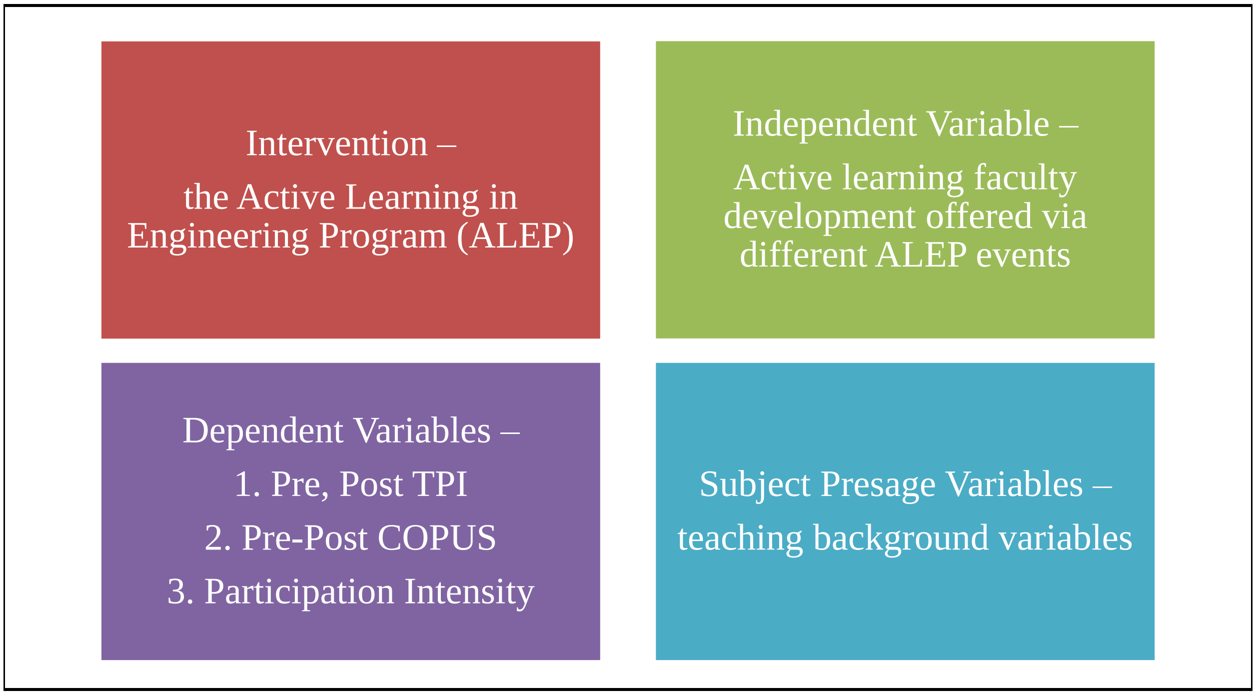
Fall 2017	**When**	**Focus**
Active Learning in Engineering Program Kick-Off	Thursday, November 16 from 5:00 to 7:00 p.m.	Program Introduction and Welcome
Pre-ALEP Qualtrics Questionnaire and Online Instructional Technology Modules	Open Mid-December	1. Teaching in an Active Learning Space 2. Overview of Instructional Technologies 3. Flipping Your Course overview 4. Overview and discussion of Americans with Disabilities Act & Universal Design
Spring 2018	**When**	**Focus**
Active Learning Workshop 1	Mid to late January	Introduction to Active Learning - designing and adopting active learning strategies, managing active learning and practice.
Community of Scholars 1	Mid-February	Role of the instructor and Managing ALS
Active Learning Workshop 2	Mid to late February	Implementation of Active Learning – adopting and adapting teaching strategies, course design and practice.
Community of Scholars 2	Early-March	Activities & assignments in ALS; Working with groups
Active Learning Workshop 3	Early to mid-April	Share Out of Active Learning course ideas - assessing learning in active learning spaces, looking ahead and sharing out course ideas.
Summer 2018	**When**	**Focus**
Technology Training Clinics	Late spring, summer	Small group opportunity for more hands-on training with the classroom technology
One-on-One practice teaching sessions in ZACH classrooms	August – as soon as building opened	Allow the opportunity for targeted, individualized support

Study Variables

This study's independent variable was the intervention, the ALEP's faculty development offerings. The dependent variables, or variables that were tested and measured, were a participant's pre-post TPI, their pre-post COPUS classroom observations, and their ALEP participation intensity score. This study focused on a posteriori issue. The researcher is cognizant there is a wide and diverse number of a priori presage variables, including an instructor participant's pedagogical training, teaching background, and/or industry experience, that could not be controlled for in this study (Dunkin and Biddle, 1974). Figure 8 shows this study's intervention and variables.

Figure 8

Study Variables



Instrumentation

The researcher chose two different instruments to collect study data – the TPI and the COPUS. Each instrument provided a different purpose, as well as required a different treatment of the data and analytic approach.

The Teaching Practices Inventory (TPI)

The researcher used the published, open-source TPI (Wieman & Gilbert, 2014) as a pretest-posttest measure to characterize an engineering instructor participant's perception of teaching practices used in a lecture-type course before and after participation in the ALEP. The TPI is an electronic questionnaire administered using Qualtrics, inviting instructors to reflect on their teaching practices across multiple categories. It requires 10 to 15 minutes to complete and is administered anonymously, collecting no identifying instructor information other than course prefix and number. Once complete, the 72-question inventory produces a detailed self-reported depiction of practices an instructor uses in a lecture-type course.

Data collected from the TPI fall into eight specific teaching practices categories: (1) course information provided, (2) supporting materials provided, (3) in class features and activities, (4) assignments, (5) feedback and testing, (6) other, (7) training and guidance of teaching assistants, and (8) collaboration or sharing in teaching (Wieman & Gilbert, 2014). The ALEP research needs align with the TPI's purpose - allows instructors to inventory and reflect on their teaching practices used in typical lecture-type classes as a means of gauging the extent that evidence-based teaching strategies are being implemented in engineering classes.

Because it is difficult to determine from the raw TPI data the extent and type of use of the included teaching practices, the TPI is accompanied with a scoring rubric, in which point values have been assigned to each of the 72 inventory items. The scoring rubric extracts from a course's TPI data an "extent of use of research-based teaching practices (ETP)" score (Wieman & Gilbert, 2014, p. 556). An ETP is reported for each of the eight inventory categories, as well as for the class as a whole. The rubric points are assigned to teaching practices for which there is research supporting the practices use improves student learning, thus indicating it as a research-based teaching practice.

Validity and Reliability Measures

"Validity revolves around the defensibility of the inferences researchers make from the data collected through the use of an instrument" (Fraenkel et al., 2015, p. 113). A more layperson definition is – for instrument scores to be considered valid, the instrument must measure what it is intended to measure. An instrument's reliability revolves around its repeatability – for an instrument's scores to be considered reliable, the instrument must give consistent results across administrations (Fraenkel et al., 2015).

The TPI was developed and validated using two major iterations, followed by one final revision round, beginning in 2007. It was developed at the University of British Columbia as a means of characterizing teaching practices in use in their science departments. The work was supported through and took place at the launch of Carl Wieman's Science Education Initiative (Wieman, 2017). The TPI was created relying on the authors' extensive knowledge of the educational research literature and their vast work with higher education science instructors and faculty development. Several hundred

University of British Columbia faculty were involved, over six years, in the TPI's development and refinement.

The TPI is an inventory in the conventional sense of the word, parlaying a list of the potential teaching strategies present in a course for an instructor to mark as present or not. The authors explain that for the TPI's construct to be valid, it must contain the entire set of teaching strategies commonly or occasionally used in a STEM classroom. "To be valid as an inventory, the TPI has to accurately characterize the range of teaching practices used in a course when an instructor makes a good faith effort to complete the inventory" (Wieman & Gilbert, 2014, p. 553).

For validity purposes, the TPI's authors worked to ensure that instructors would interpret the listed teaching strategies consistently and accurately, as well as to make sure that the inventory listed all the potential teaching strategies a STEM instructor could possibly use in class. As the inventory is a checklist of sorts, the usual psychometric tests for validity do not apply. Lastly, the TPI only provides a list of teaching strategies used by an instructor in his/her class; it provides no data about the quality of implementation.
The TPI's eight question categories - (1) course information provided, (2) supporting materials provided, (3) in class features and activities, (4) assignments, (5) feedback and testing, (6) other, (7) training and guidance of teaching assistants, and (8) collaboration or sharing in teaching - were created based on usability interviews and feedback received from the hundreds of instructors who piloted the TPI during its extensive inventory iterations. These eight categories and the survey's format were chosen for user ease and are not based on any theoretical constructs. Also, to improve the accuracy and consistency in survey responses, the authors intentionally designed the inventory to be very objective,

trying to minimize the need for subjective judgements when interpreting listed teaching practices.

The Classroom Observation Protocol for Undergraduate STEM (COPUS)

The researcher used the published COPUS observation protocol to collect pre- and post-ALEP classroom behaviors observation data to use for analysis in all three study research questions. (Smith et al., 2013). The COPUS observation protocol was adapted out of necessity, over a two-year period, from the Teaching Dimensions Observation Protocol (TDOP). The TDOP's purpose is similar to the COPUS' purpose, but the actual instrument is quite complex and requires an extensive three-day training for reliable use (Hora at al., 2013). The COPUS protocol development began in late 2011 as a joint effort by faculty at both the University of British Columbia and the University of Maine. The University of British Columbia work was supported through Carl Wieman's Science Education Initiative (Wieman, 2017). This group was interested in collecting information regarding teaching practices used in STEM undergraduate classrooms to assist in supporting institutional change using an instrument less complex than the TDOP. The COPUS underwent many iterations and extensive testing as part of Wieman's Science Education Initiative focused on improving science faculty's teaching (Wieman et al., 2010).

This study's observational needs align with the COPUS's purpose – to document both instructor and student behaviors in STEM classrooms in order to compare instructional practices longitudinally across both the treatment group and the control group to determine if there are differences in teaching strategies utilized in the classroom between the ALEP instructor participants and the non-ALEP instructors. As described by its developers, the "COPUS is easy to learn, characterizes nonjudgmentally what instructors and students are doing during a class, and provides data that can be useful for a wide range of applications” (Smith et al., 2013, p. 626). It is used to document the co-occurrence of both 12 instructor behaviors and 13 student behaviors during each two-minute interval of a class session using the behavior codes described in Table 4. See Appendix D for a sample COPUS observation instrument.

Table 4

COPUS Student and Instructor Code Descriptions

1. Students doing	
L	Listening to instructor/taking notes, etc.
Ind	Individual thinking/problem solving. Only mark when an instructor explicitly asks students to think about a clicker question or another question/problem on their own.
CG	Discuss clicker question in groups of 2 or more students
WG	Working in groups on worksheet activity
OG	Other assigned group activity, such as responding to instructor question
AnQ	Student answering a question posed by the instructor with rest of class listening
SQ	Student asks question
WC	Engaged in whole class discussion by offering explanations, opinion, judgment, etc. to whole class, often facilitated by instructor
Prd	Making a prediction about the outcome of demo or experiment
SP	Presentation by student(s)
TQ	Test or quiz
W	Waiting (instructor late, working
O	Other – explain in comments
2. Instructor doing	
Lec	Lecturing (presenting content, deriving mathematical results, presenting a problem solution, etc.)
RtW	Real-time writing on board, doc. projector, etc. (often checked off along with Lec)
FUp	Follow-up/feedback on clicker question or activity to entire class
PQ	Posing non-clicker question to students (non-rhetorical)
CQ	Asking a clicker question (mark the entire time the instructor is using a clicker question, not just when first asked)
AnQ	Listening to and answering student questions with entire class listening
MG	Moving through class guiding ongoing student work during active learning task
1o1	One-on-one extended discussion with one or a few individuals, not paying attention to the rest of the class (can be along with MG or AnQ)
D/V	Showing or conducting a demo, experiment, simulation, video, or animation
Adm	Administration (assign homework, return tests, etc.)
W	Waiting when there is an opportunity for an instructor to be interacting with or observing/listening to student or group activities and the instructor is not doing so
O	Other – explain in comments

The COPUS’ purpose for use in this study was to nonjudgmentally characterize what instructors and what students were doing during an engineering class session. The researcher wanted to determine, both pre- and post-, the prevalence of different instructor and student behaviors in both the ALEP and non-ALEP samples to determine if differences exist between the two groups, either between or within, in the teaching strategies used in the classroom. To determine behavior frequencies, all observed behavior codes were marked on the COPUS instrument in two-minute intervals over a 50-minute classroom observation.

Observer Training

A salient COPUS attribute is its ease of use for those with little or no classroom observation background or experience. The authors strove to develop a protocol that could be reliably used with minimal training time. The following is a condensed COPUS training summary provided for the three-person observation team who conducted the Fall 2018 ALEP classroom observations for both the treatment group and the control group. The author created step-by-step observer training guide is included in Appendix E.

Per COPUS protocol, the researcher led one 90-minute observer training session. The training session focused on developing a working knowledge and familiarity with both the COPUS behavior codes and the observation instrument. The researcher and two observer trainees spent time discussing and role-playing the codes as a way of calibrating a common understanding of what each code looks like in a classroom setting. Once all three observer training participants were comfortable and confident in their discussion of the COPUS behavior codes, the three continued calibration using a COPUS protocol recommended two-minute YouTube clip showing a straightforward, mainly lecture-based, classroom video to practice individually marking only the instructor behavior codes on the COPUS observation instrument. As this was only a two-minute clip, it only accounted for just one two-minute interval row on the observation instrument. This allowed observer trainees to focus solely on the video and observation instrument, not worrying about watching a timer as well. Once the two-minute YouTube clip was up, the observer training group discussed what instructor behaviors they saw in the clip to come to a more accurate calibration in behavior code marking. From a two-minute classroom video clip, the group moved to a more complicated COPUS protocol recommended eight-minute YouTube video clip, again completing only the instructor behaviors section of the observation instrument, but as a group using a shared timer. The group paused periodically to discuss any unclear observed behaviors. This viewing/coding session was followed up with another calibration discussion with each person in the group taking turns sharing what they saw and what they coded on their instrument in the two-minute interval rows. After the eight-minute instructor-specific group coding session, the group moved into another COPUS protocol recommended eight-minute YouTube video clip coding session containing both instructor and student behaviors. The same procedure was followed for this practice coding session as was previously. Again, the group paused periodically to discuss any unclear observed behaviors, either instructor and/or student. This viewing/coding session was also followed up with another calibration discussion with each person in the group taking turns sharing what they saw and what they coded on their instrument in the two-minute interval rows. After completing the formal 90-minute observation training session, the researcher paired with each trainee for one formal paired instructor classroom observation. For each of the formal paired instructor classroom observations, inter-rater reliability (IRR) was calculated. More on how IRR was calculated will be discussed below.

Observer trainees were not made aware of whether an instructor was part of the treatment group or the control group. Prior to the observation, the researcher entered into the COPUS instrument the required classroom observation information – Date:, Class:, Instructor, No. Students:, Observer Name:. Appendix F outlines the researcher's supplemental observation instructions, step-by-step, for the observer to follow to complete each COPUS instrument as part of an individual classroom observation. During a scheduled classroom observation, the observer completed the COPUS instrument using his or her own laptop computer. Observers used either his or her laptop computer clock or cellphone timer to keep track of the two-minute intervals, beginning as soon as the class period's scheduled start time, not when the instructor actually began class. Regardless of the class session's duration, observations were conducted for the first 50 minutes of class.

Validity and Reliability

Validity of Measures. The COPUS is purely a behavior frequency observation tool, with the observer marking, in two-minute intervals, both the instructor and student behaviors seen, using the provided behavior codes. See Table 4 above for the COPUS instructor and student codes and accompanying descriptions. These behavior codes and descriptions were not intended by the authors or subsequent researchers to judge the quality of instruction or to be linked to any certain external criteria other than the provided behavior description. Because of this, the primary COPUS validity criterion, the extent to which the instrument measures what it claims to measure (Kelly, 1927), lies in the STEM faculty and K-12 teacher experts and observers who worked on its development see it as capturing the full range of typical classroom behaviors for both instructors and students. This content-related validity, the extent to which the instrument contains appropriate content, and face validity, the extent to which the instrument appears to measure what it claims (Nevo, 1985), were cemented as part of the COPUS' extensive iteration testing, guided by feedback from the Science Education Specialists, the K-12 teacher experts, and the instruments three authors who all have vast knowledge and extensive experience working in STEM instruction and conducting classroom observations (Smith et al., 2013). Since its release in 2013, many additional studies have found the classroom observation data collected using the COPUS to validly and reliably describe teaching practices in STEM lecture classrooms (Akiha et al., 2018; Lewin et al., 2016; Lund et al., 2015; Stain et al., 2018). In addition, there exists in the literature a strong evidence of the COPUS' widespread use. Stains et al. (2018) provides a listing of National Science Foundation (NSF) funded projects endorsing the COPUS' use as a means of also supporting its validity including,

> (1) Described by a lead program director at the NSF as the number one protocol mentioned in the Improving Undergraduate STEM Education (IUSE) proposals,
> (2) Used as a measure of impact by the Transforming Education, Stimulating Teaching and Learning Excellence (TRESTLE) project, an NSF-funded project across seven institutions and multiple STEM disciplines, and
> (3) Used by the Automated Analysis of Constructed Response (AACR) project, an NSF-funded project at six different Ph.D. granting institutions, to measure the impact that Faculty Learning Communities and collaboration on instructional activities has on biology faculty teaching practices. (Supplementary Materials, p.4)

Reliability of Measures. Along with the instrument's validity, the COPUS developers strove to create an instrument that allowed for high IRR when used after completing the prescribed protocol training. Inter-rater reliability is the extent to which multiple raters, in this case two or more observers, are in agreement. It examines the level of variability across observers using the same instrument (Landis & Koch, 1977). The COPUS developers compared observer reliability across all 25 COPUS codes within the instrument by calculating Cohen's kappa IRR score (Cohen, 1960). The COPUS training materials detail the procedure for calculating Cohen's kappa IRR score using the observation instruments from a paired instructor classroom observation. As the use of and research surrounding the COPUS has grown, there exist online COPUS analysis tools that will calculate uploaded observer pairs Cohen's kappa IRR score. The authors found an average kappa score range, for both the authors and assisting K-12 teacher experts, of 0.79 to 0.87 (Smith et al., 2013). These are considered very high kappa values and therefore indicate good IRR (Landis & Koch, 1977). Also, because both groups had average kappa scores in the very high range, this indicates the COPUS' scores show reliability across observer groups as well.

Inter-rater Reliability

The researcher used the online NSF-funded COPUS Analyzer to calculate the IRR for this study's formal paired instructor classroom observations. Both formal pair observations ended up being very simple, straight-forward classroom observations with little variation in the instructional strategies used during the observed class time. The IRR for one of the trained observers and the researcher was a kappa score of 0.94. The IRR for the other trained observer and the researcher was 0.95. Kappa scores closer to 1.0 are indicative of greater consistency in the observation codes marked by the two observers. Most of the observation coding differences came during the first 10 minutes of class time, allowing for the researcher and the trained observer to note discrepancies early and calibrate during the observation.

Treatment of the Data

Treatment of this study's data falls into two categories, (1) treatment of the TPI data and (2) treatment of the COPUS data.

The TPI Data

Once TPI administration concluded for each individual time-period, both the pre- and post-, the researcher downloaded the data out of Qualtrics as an Excel spreadsheet. The data was then read over to both secure the integrity of the data set and to gain an overall sense of the data. The TPI Qualtrics file available on the University of British Columbia's Carl Wieman Science Education Initiative webpage (https://cwsei.ubc.ca/resources/tools/tpi) has embedded 'ETP scoring'. The 'ETP scoring' provided for each individual TPI participant, now individual rows on the Excel spreadsheet, includes an overall score, as well as a score for each of the eight inventory categories.

Overall General TPI Reporting

For the 31 ALEP engineering instructor participants who completed a pre-ALEP TPI, the overall scores ranged from 21 to 56 out of a possible 67, with a mean pre-ALEP overall TPI score of 36.9 (+/- 9.0). The pre-ALEP TPI Category III. In-class Feature and Activities, the category the researcher was interested in for this study, scores ranged from 1 to 15 out of a possible 15, with a mean pre-ALEP score of 7.4 (+/- 3.3). The pre-ALEP TPI responses to the question regarding fraction of class time spent lecturing had two (6.4%) choose 0-20%, six (19.3%) choose 20-40%, eight (25.8%) choose 40-60%, seven (22.6%) choose 60-80%, and eight (25.8%) choose 80-100%.

For the 25 ALEP engineering instructor participants who completed a post-ALEP TPI, the overall scores ranged from 18 to 53 out of a possible 67, with a mean post-ALEP overall TPI score of 36.2 (+/- 7.4). The post-ALEP TPI Category III. In-class Feature and Activities scores ranged from 3 to 14 out of a possible 15, with a mean pre-ALEP score of 8.2 (+/- 3.). The post-ALEP TPI responses to the question regarding fraction of class time spent lecturing had three (12.0%) choose 0-20%, five (20.0%) choose 20-40%, six (24.0%) choose 40-60%, seven (28%) choose 60-80%, and four (16%) choose 80-100%. Table 5 shows the frequency and percentages for the pre-ALEP and post-ALEP instructor participants' self-reported TPI responses to the fraction of class time they spend lecturing.

Table 5

Pre- and Post-ALEP Instructors Participants' Self-Reported TPI Responses to Fraction of Class Time Spent Lecturing

	Pre-ALEP		Post-ALEP	
Self-Reported TPI % Time Lecture	*n*	%	*n*	%
0-20%	2	6.4	3	12.0
20-40%	6	19.3	5	20.0
40-60%	8	25.8	6	24.0
60-80%	7	22.6	7	28
80-100%	8	25.8	4	16
Total	31	100	25	100

The COPUS Data

Treatment of the COPUS data included collecting, organizing, screening, and reading the observation data to both secure the integrity of the data set and to gain an overall sense of the data. Initially, each ALEP classroom observation was conducted using an individual COPUS instrument, on which the observation data was collected in raw form. The raw observation data was cleaned and screened by the researcher for errors - missing values and/or erroneous values - that may have been entered.

The researcher chose to follow an analytical approach published by Stains et al. (2018), a large, multi-institutional research group also investigating the instructional practices used in STEM classrooms. This group found that solely documenting the frequency of instructor and student behaviors does little to accurately portray the potential multitude of teaching strategies being implemented in addition to or in place of one another. To provide a richer, more holistic instructor profile that goes beyond simple behavior frequency counts, Stains et al. (2018) conducted latent profile analysis on over 2,000 STEM classroom COPUS observation instruments to create clusters based on the inclusion of four of the COPUS' 12 instructor behavior codes - lecture, posing questions, clicker questions, and one-on-one work with students - and the inclusion of four of the COPUS' 13 student behavior codes - group work on clicker questions, group work on worksheets, other group work, and asking questions. Table 6 shows the instructor and student COPUS behavior codes Stains et al. (2018) included in their content latent profile analysis.

Table 6

Instructor and Student COPUS Behavior Codes Included in Content Latent Profile Analysis

Instructor Behaviors Codes	Student Behavior Codes
Lecture (Lec)	Group work on clicker questions (CG)
Posing Questions (PQ)	Group work on worksheets (WG)
Clicker Questions (CQ)	Other group work (OG)
One-on-one work with students (1o1)	Asking questions (SQ)

In their research, Stain et al. (2018) chose these eight behaviors because “they were observed with adequate heterogeneity, were not highly correlated with each other, and were likely to be key strategies in active or nonactive learning environments” (p. 1469). These researchers found seven resulting clusters, each portraying a unique instructional profile. Table 7 displays each resulting cluster and its definition based on Stain et al.’s (2018) findings.

Table 7

Instructional Profile Clusters and Cluster Definitions (adapted from Stain et al., 2018)

Cluster	Cluster Definition
Cluster 1	No observed student involvement except sporadic questions from and to the students
Cluster 2	Included clicker questions sometimes associated with group work
Cluster 3	Included lecture supplemented with more student-centered strategies such as “Other group activities”
Cluster 4	Included lecture supplemented with more student-centered strategies such as “Clicker questions with group work”
Cluster 5	Included a variety of group work strategies consistently used
Cluster 6	Included strategies incorporating group worksheets and one-on-one assistance from the instructor
Cluster 7	Included a variety of group work strategies but with less consistent usage

These seven resulting clusters could be grouped into three overarching instructional profiles based on common teaching practices. The grouped instructional profiles are: (1) “Didactic” style (clusters 1 and 2) characterizes a classroom with more than 80% of class time spent on instructor lecture, (2) “Interactive Lecture” style (clusters 3 and 4) characterizes a classroom where instructors supplement lecture with more student-centered activities, and (3) “Student-Centered” style (clusters 5, 6, and 7) characterizes a classroom where instructors incorporate student-centered activities for large portions of class time (Stain et al., 2018). Table 8 shows the three grouped instructional profiles and Stain et al.’s (2018) definition for each grouped profile.

Table 8

Grouped Instructional Profiles and Profile Definitions

Grouped Instructional Profile	Profile Definition
Didactic Style	Clusters 1 and 2 - Characterizes a classroom with more than 80% of class time spent on instructor lecture
Interactive Lecture Style	Clusters 3 and 4 - Characterizes a classroom where instructors supplement lecture with more student-centered activities
Student-Centered Style	Clusters 5, 6, and 7 - Characterizes a classroom where instructors incorporate student-centered activities for large portions of class time

As part of an NSF Career Grant, Stains created the online COPUS Analyzer tool, www.copusprofiles.org, to analyze uploaded de-identified COPUS observation data. Since the research group's instructional profile development, Stains and Harshman updated the COPUS Analyzer to include the corresponding COPUS Profile cluster score as part of the reported analysis.

Once this study's ALEP observation data collection was complete, to prep the already cleaned COPUS data for an initial analysis using the COPUS Analyzer, an Excel macro was created to combine all 115 pre- and 126 post- individual observation instruments into one large spreadsheet formatted based on the COPUS Analyzer's Minute-by-Minute Template. See Appendix G for a sample Minute-by-Minute Template. As part of the macro creation, several COPUS data formatting changes were made to accommodate the analytical approach chosen. The formatting changes included:

1. The original x's used by each observer to mark on the COPUS an observed instructor or student behavior were changed to 1's; 0's were added to boxes originally left blank due to no observed instructor or student behavior.

2. The COPUS’ two-minute timeframe labels (e.g., 0-2, 2, 4, 6, 8-10) were changed to a time counter (i.e., 1, 2, 3…25).
3. What was originally listed in the COPUS’ “Class:” cell was separated into “course_subject_code” and “course_number”

Once the macro was complete, the combined raw COPUS data was again cleaned and screened by the researcher to make sure the data was transferred over correctly during the Excel macro creation process. Before the macro was ready to upload to the COPUS Analyzer, the original COPUS variables needed additional formatting modifications to those required in the Minute-by-Minute Template, including:

1. The initial instructor code was further de-identified with an instructor alphanumeric code.
2. Using the observation date, a “semester_recorded” column was created and hand coded by the researcher – either Spring or Fall.
3. Also using the observation data, a “year_recorded” column was created and hand coded by the researcher – 2018.
4. A “class_layout” column was created and hand coded by the research based on the observation room’s configuration – fixed or flexible. Fixed is defined as a classroom where the chairs and/or tables are secured to the floor and are immovable. Flexible is defined as a classroom where the chairs and/or tables are on wheels and are movable.
5. The COPUS’ “3. Engagement” columns and “Comments” columns were not included in the macro.

This study's Excel macro, now in the in the COPUS Analyzer's Minute-by-Minute Template, was then uploaded to the COPUS Analyzer website. The COPUS Analyzer produced a COPUS Summary report, in the form on an Excel spreadsheet, with the COPUS instructor and student behaviors as columns and each individual instructor observation as a row, reporting the overall percent of two-minute observation intervals spent on each COPUS behavior code. See Appendix H for a sample COPUS Analyzer COPUS Summary report. Additionally, each individual instructor observation row reported four collapsed instructor behavior code percentages – (1) Presenting, (2) Guiding, (3) Administrative, and (4) Instructor Other – and four collapsed student behavior code percentages – (1) Receiving, (2) Talking, (3) Working, and (4) Student Other – calculated to determine each instructor's cluster number 1 through 7. Table 9 shows the collapsed COPUS behavior codes the COPUS Analyzer reports on the COPUS Summary for each individual COPUS observation uploaded.

Table 9

Collapsed COPUS Behavior Codes

Collapsed Code	Included COPUS Behavior Codes
Instructor Codes	
Presenting	Lec, RtW, or D/V
Guiding	FUp, PQ, CQ, T-AnQ, MG, 1o1
Administrative	Adm
Instructor Other	T-W, T-O
Students Codes	
Receiving	L
Talking	S-AnQ, SQ, WC, SP
Working	Ind, CG, WG, OG, Prd, TQ
Student Other	S-W, S-O

Overall General COPUS Reporting

The researcher conducted 115 Spring 2018 pre-ALEP observations from 35 different courses taught by 59 individual instructors across 15 engineering departments. Texas A&M's CoE limits engineering class size to less than 100, so all but two observed classes had less than 100 students. Observed class size ranged from 8 to 122 students, with an average observed class size being 61.4 (+/- 21.7). The classrooms observed fell into two categories – fixed furniture or flexible furniture. Of the 115 Spring 2018 pre-ALEP conducted observations, 41 of them were in classrooms with fixed furniture and 74 of them were in classrooms with flexible furniture. The three most common instructor behaviors were lecture (a mean of 61.8% +/-32.1% of the total 2-minute COPUS intervals of a 50-minute class observation), writing in real time (58.4% +/- 31.8%), and posing non-clicker/non-rhetorical question to students (29.0% +/- 18.8%). For the treatment group's 61 of the 115 observations, the three most common instructor behaviors were lecture (a mean of 52.5% +/- 35.0% of the total 2-minute COPUS intervals of a 50-minute class observation), writing in real time (52.3% +/- 33.7%), and posing non-clicker/non-rhetorical question to students (28.1% +/- 20.0%). For the control group's 54 of the 115 observations, the three most common instructor behaviors were lecture (a mean of 72.4% +/- 24.8% of the total 2-minute COPUS intervals of a 50-minute class observation), writing in real time (65.2% +/- 28.2%), and posing non-clicker/non-rhetorical question to students (30.0% +/- 17.8%).

The researcher and two trained observers conducted 126 Fall 2018 post-ALEP observations from 39 different courses taught by 61 individual instructors across 15 engineering departments. Texas A&M's CoE limits engineering class size to less than 100, so none of the classes observed had more than 100 students. Observed class size ranged from 5 to 98 students, with an average observed class size being 56.7 (+/- 23.2). The classrooms observed fell into two categories – fixed furniture or flexible furniture. Of the 126 Fall 2018 post-ALEP conducted observations, 20 of them were in classrooms with fixed furniture, 14 ALEP instructor participants and 6 non-ALEP instructors, and 106 of them were in Zachry's new learning studios with flexible furniture. The three most common instructor behaviors were writing in real time (a mean of 78.9% +/-26.1% of the total 2-minute COPUS intervals of a 50-minute class observation), lecture (58.4% +/- 30.0%), and posing non-clicker/non-rhetorical question to students (32.7% +/- 24.5%). For the treatment group's 68 of the 126 observations, the three most common instructor behaviors were writing in real time (a mean of 72.8% +/- 27.5% of the total 2-minute COPUS intervals of a 50-minute class observation), lecture (52.0% +/- 31.5%), and posing non-clicker/non-rhetorical question to students (36.1% +/- 26.4%). For the control group's 58 of the 126 observations, the three most common instructor behaviors were writing in real time (a mean of 86.0% +/- 22.5% of the total 2-minute COPUS intervals of a 50-minute class observation), lecture (65.9% +/- 26.5%), and posing non-clicker/non-rhetorical question to students (29.8% +/- 21.6%).

Table 10 shows the percentages and standard deviations for the three most common pre-ALEP post-ALEP COPUS instructor behavior codes overall, and then broken down into ALEP instructors and non-ALEP instructors.

Table 10

Three Most Common Pre-ALEP and Post-ALEP COPUS Instructor Behaviors Reported for All Instructor Participants, ALEP Instructor Participants, and Non-ALEP Instructors

	All Instructor Participants		ALEP Instructors		Non-ALEP Instructors	
Pre-COPUS Instructor Codes	%	SD	%	SD	%	SD
Lecture	61.8	32.1	52.5	35.0	72.4	24.8
Writing in real time	58.4	31.8	52.3	33.7	65.2	28.2
Non-rhetorical questions	29.0	18.8	28.1	20.0	30.0	17.8
Post-COPUS Instructor Codes						
Writing in real time	78.9	26.1	72.8	27.5	86.0	22.5
Lecture	58.4	30.0	52.0	31.5	65.9	26.5
Non-rhetorical questions	32.7	24.5	36.1	26.4	29.8	21.6

Both groups, the ALEP instructor participants and the non-ALEP instructors, saw a change in the topmost common post-COPUS instructor codes, from lecture to writing in real time.

Research Questions

Research Question 1

Investigative Design

The researcher wants to increase engineering instructors' use of evidence-based teaching strategies. To determine the ALEP's effectiveness in supporting engineering instructors' transition to a more learner-centered pedagogical paradigm, this study's research question one inquired if significant differences exist between in the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors. It also inquired if there were significant changes in ALEP instructor participants teaching strategies utilized after Program participation. More simply stated, looking pre- to post-, did the invention stick or did it leak out? This question's null hypothesis was – No differences exist in the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors.

Research question one used a two-group quasi-experimental research design with a pretest-posttest observational methodology. In a two-group pretest-posttest design, both groups, the treatment group and the control group, are measured or observed before and after being exposed to an intervention of some sort (Fraenkel et al., 2015). This study's intervention was the ALEP. The researcher compared the treatment group, the ALEP instructor participants, and the control group, the non-ALEP instructors, to see if differences existed, *between* the two groups, in the classroom teaching strategies used. Research question one also used a one-group quasi-experimental research design with a pretest-posttest observational methodology, including only the treatment group. In a one-group pretest-posttest design, only one group, the treatment group, is measured or observed both before and after being exposed to an intervention of some sort (Fraenkel et al., 2015). The researcher compared the treatment group, the ALEP instructor participants, before and after the intervention to see if changes existed, *within* the group, in the classroom teaching strategies used.

Participants

Research question one's sample contained both the study's treatment group and control group. The treatment group included 32 ALEP instructor participants; the control group contained 48 non-ALEP instructors. Research question one's inclusion criteria were engineering instructors who taught a course in both the Spring 2018 and Fall 2018 semesters. Of the treatment group's 32 participants, all 32 were included in the between groups sample, but only 31 were included in the within groups sample. One treatment group instructor did not teach in Spring 2018 but did in Fall 2018. This meant they had zero Spring 2018 observations and two Fall 2018 observations, so the researcher couldn't match pre- and post- observations required for the within group analysis. Of the control group's 48 participants, 28 participants were included in the between groups pretest sample and 29 participants were included in the between groups posttest sample. Nine control group participants were included in both the pretest and posttest samples. So, of the original 48 control group participants, only nine were included in the within groups sample.

Based on research question one's design and hypothesis, if the researcher assumes there is a moderate effect size of 0.5 for *t*-tests looking at differences between two dependent groups at a 0.05 significance level with 80% power, the desirable sample size 34 was instructor participants.

Procedures

Research question one involved the treatment group and the control group in research during the Spring 2018 and Fall 2018 semesters. One instrument was used for data collection: the COPUS – a protocol for pre- and post-classroom observations used to monitor the treatment group's adoption of evidence-based teaching strategies into his or her course. Spring 2018 served as the pre-ALEP semester; Fall 2018 served as the post-ALEP semester. Two pre-ALEP classroom observations were conducted solely by the researcher using the COPUS observation instrument during the Spring 2018 semester; two post-ALEP observations were conducted by the researcher and two other trained observers using the COPUS observation instrument during the Fall 2018 semester. Observations were completed using the COPUS to document the instructor and student classroom behaviors of both the treatment group and the control group instructor participants.

Each instructor participant's class was observed by an individual observer twice a semester at mutually agreed upon times. The researcher emailed the individual instructor participants in both the treatment and the control groups to arrange the classroom observations. During the Spring 2018 semester, the research created a master observation schedule she followed to complete 115 observations. Of the 115 Spring 2018 observations conducted, the 31 treatment group participants were observed 61 times, as one ALEP instructor participant was only able to be observed once due to scheduling conflicts. Of the 115 Spring 2018 observations conducted, the 28 control group participants were observed 54 times, as two non-ALEP instructors were only able to be observed once due to scheduling conflicts. During the Fall 2018 semester, the researcher created a master observation schedule she and the two trained observers followed to complete 126 observations. Of the 126 Fall 2018 observations conducted, the 32 treatment group participants were observed 68 times, as two ALEP instructor participants taught two courses giving them a total of four observations each. Of the 126 Fall 2018 observations conducted, the 29 control group participants were observed 58 times. Calendar invites were sent from the research to the two trained observers letting them know who, when, and where they would be observing. The two trained observers were not privy to which of the engineering instructors they observed were part of the treatment group or the match control group.

Classroom observations were conducted during the first 50-minutes of a class session, marking in two-minute intervals what the instructors were doing and what the students were doing using the 29 predetermined COPUS classroom behavior codes. Multiple codes were marked in the same two-minute time interval to accurately capture all instructor and all student behaviors. During a classroom observation, the observer used his or her own laptop computer to complete the COPUS observation tool, an Excel spreadsheet. The researcher pre-completed the required instructor and class demographic information located at the top of each COPUS spreadsheet. Appendix F outlines the researcher’s supplemental observation protocol instructions, step-by-step, for the observers to follow to complete each COPUS observation tool as part of an individual classroom observation. The observer used his or her laptop computer’s clock or cellphone timer to keep track of the two-minute intervals, beginning as soon as the class session started, not when the instructor began class. Regardless of class session duration, observations were only conducted for the first 50 minutes of a class session.

Analytical Approach

As each individual instructor participant had two pre-ALEP COPUS observations and two post-ALEP COPUS observations, the researcher treated the COPUS Analyzer reported cluster score, 1 through 7, as scale data and calculated each instructor participant's pre-ALEP mean cluster score and post-ALEP mean cluster score. SPSS was used to run quantitative statistical analysis based on the research question's methodology. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were run for the data to check for violations of assumptions. A key assumption of the *t* test is that variances are approximately equal, the assumption of homogeneity of variances. The Levene's test for Equality of Variances did not show any significant differences for either the Spring 2018 pre-ALEP and Fall 2018 post-ALEP mean cluster score for the treatment and control groups; thus, the assumption of homogeneous variances is not violated. Also, both group's pre- and post- skewness values are less than one, which indicates that both group's mean cluster scores for both time periods are approximately normal. Thought the *t* test is quite robust to violations of these two assumptions, the researcher checked for them before running any parametric analyses.

To inquire if significant differences exist between groups and if significant changes exist within the treatment group in the classroom teaching strategies utilized, the researcher originally wanted to do a regression analysis comparing changes. The data collection did not support a multiple regression analysis, though, due to the control group sample size with both a pre- and post-COPUS observations were underpowered to detect effects (n = 9). The researcher chose to conduct both independent samples and paired samples *t*-tests using the mean cluster score for the treatment and control group's pre-ALEP and post-

ALEP COPUS cluster score. The researcher does recognize that there are limitations to this analytic approach, but was the chosen approach based on the data collected. For the between group analysis, two sets of independent samples *t*-tests were conducted. One independent samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores for the ALEP instructor participants (*n* = 31) and the non-ALEP instructors (*n* = 28). The other independent samples *t*-test compared the Fall 2018 post-mean COPUS cluster scores for the ALEP instructor participants (*n* = 32) and the non-ALEP instructors (*n* = 29). For the within group analysis, two paired samples *t*-tests were conducted. One paired samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores and the Fall 2018 post-mean COPUS cluster scores for ALEP instructor participants (*n* = 31). The other paired samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores and the Fall 2018 post-mean COPUS cluster scores for non-ALEP instructors (*n* = 9).

Data Analysis

Using Stain et al.'s (2018) grouped instructional profiles of didactic, interactive lecture, and student-centered instruction, Table 11 shows the frequencies for the Spring 2018 pre-ALEP and Fall post-ALEP resulting instructional profiles based on mean COPUS cluster scores for both the ALEP instructor participants, the treatment group, and non-ALEP instructors, the control group. Reported results are frequency percentages for the number of people (*n*) in each cluster category. For ease of reading, frequency percentages have been rounded to the nearest tenth percent.

Table 11

Instructional Profiles Based on Mean COPUS Cluster Scores for ALEP Instructor Participants and Non-ALEP Instructors for Spring 2018 Pre- and Fall 2018 Post-

	Pre-ALEP		Post-ALEP	
Instructor Profile – Treatment Group	*n*	%	*n*	%
Didactic Style – Clusters 1 & 2	11	35.5	13	40.6
Interactive Lecture Style – Clusters 3 & 4	16	51.6	15	46.9
Student-Centered Style – Clusters 5, 6, & 7	4	12.9	4	12.5
Total	31	100%	32	100%
Instructor Profile – Control Group				
Didactic Style – Clusters 1 & 2	21	75	15	51.7
Interactive Lecture Style – Clusters 3 & 4	7	25	12	41.4
Student-Centered Style – Clusters 5, 6, & 7	0	0	2	6.9
Total	28	100%	29	100%

Two separate independent samples *t*-tests were conducted to determine if between group differences exist in the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors. One independent samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores for the ALEP instructor participants and the non-ALEP instructors. The other independent samples *t*-test compared the Fall 2018 post-mean COPUS cluster scores for the ALEP instructor participants and the non-ALEP instructors. Due to teaching schedules, only nine non-ALEP engineering instructors were common to both the pre- and post-ALEP control group samples. Table 12 shows that ALEP instructor participants were statistically significantly different from non-ALEP instructors on Spring 2018 pre-ALEP mean COPUS cluster scores, $t(57) = -2.98$, $p = .004$. Inspection of the two group means indicates that the average Spring 2018 pre-ALEP mean

COPUS cluster score for non-ALEP instructors (M = 1.86) is significantly lower than the score (M = 2.79) for ALEP instructor participants. The difference between the means is .93 on a 7-point scale. The effect size d is approximately .8, which is a large to much larger than typical size for effects in the behavioral sciences (Cohen, 1988). For the post-ALEP comparison, the control group's mean COPUS cluster score appeared to increase almost a full point, from 1.86 to 2.76, while the treatment group's mean COPUS cluster score appeared to increase .30, from 2.79 to 3.09. The ALEP instructor participants did not differ from non-ALEP instructors on Fall 2018 post-mean COPUS cluster scores, *t*(59) = -.97, *p* = .34. Results are reported as frequencies for the number of people (*n*), means (*M*), and standard deviation (*SD*). For ease of reading, means and standard deviations have been rounded to the nearest hundredth.

Table 12

Comparison of ALEP Instructor Participants and Non-ALEP Instructors on Spring 2018 Pre- and Fall 2018 Post- Mean COPUS Cluster Scores

	Treatment			Control			*t*			
	n	*M*	*SD*	*n*	*M*	*SD*	*t*	*df*	*p*	*d*
S18 Pre-Mean Cluster Score	31	2.79	1.40	28	1.86	.94	-2.98	57	.004*	.8
F18 Post-Mean Cluster Score	32	3.09	1.36	29	2.76	1.33	-.97	59	.336	.3

Note. *$p < .01$

To answer the first part of research question one, there were significant pre-ALEP differences, but no significant post-ALEP differences, in the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors. Though the treatment group's mean cluster score was higher than the control group's for both the pre- and post-time periods, only the Spring 2018 pre-ALEP mean cluster score was significantly higher. The treatment group's Fall 2018 post-ALEP mean cluster score was not significantly higher.

Two paired samples *t*-tests were conducted to determine if within group differences exist in the classroom teaching strategies utilized by ALEP instructor participants and non-ALEP instructors. One paired samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores and the Fall 2018 post-mean COPUS cluster scores for ALEP instructor participants. Table 13 shows that this paired samples *t*-test indicated that ALEP instructor participants had on average non-significantly higher Fall 2018 post-mean COPUS cluster scores ($M = 3.10$) than Spring 2018 pre-ALEP mean COPUS cluster scores ($M = 2.79$), $t(30) = -1.53$, $p = .137$. The other paired samples *t*-test compared the Spring 2018 pre-ALEP mean COPUS cluster scores and the Fall 2018 post-mean COPUS cluster scores for non-ALEP instructors. Table 13 also shows that this paired samples *t*-test indicated that non-ALEP instructors had on average significantly higher Fall 2018 post-mean COPUS cluster scores ($M = 3.28$) than Spring 2018 pre-ALEP mean COPUS cluster scores ($M = 2.00$), $t(8) = -3.51$, $p = .008$. The effect size d is approximately 1.2, which is a much larger than typical size for effects in the behavioral sciences (Cohen, 1988). Results are reported as frequencies for the number of people (n), means (M), and standard deviation (*SD*). For ease of reading, means and standard deviations have been rounded to the nearest hundredth.

Table 13

Paired Samples Comparison of ALEP Instructor Participants and Non-ALEP Instructors on Spring 2018 Pre- and Fall 2018 Post-Mean COPUS Cluster Scores

Treatment	*n*	*M*	*SD*	*t*	*df*	*p*	*d*
S18 Pre-F18 Post- Mean Cluster Score	31	-.31	1.12	-1.53	30	.137	.3
Control	*n*	*M*	*SD*	*t*	*df*	*p*	*d*
S18 Pre-F18 Post- Mean Cluster Score	9	-1.28	1.09	-3.51	8	.008*	1.2

Note. *$p < .01$

To answer the second part of research question one, there were no statistically significant within group differences in the classroom teaching strategies utilized by ALEP instructor participants after participation in the ALEP. Though the treatment group's post-ALEP mean cluster score appears to have increased from their pre-ALEP mean cluster score, it was not a statistically significant difference. There was a significant pre-/post- within group difference in the classroom teaching strategies utilized by the non-ALEP instructors. Due to the control group's small sample size ($n = 9$), these results should be viewed with caution. Table 14 shows the pre-/post- change in mean COPUS cluster score for both the ALEP instructor participants and the non-ALEP instructors. For the ALEP instructor participants (*n* = 31), 25% had 0 change in their post-ALEP mean cluster score and 47% had a positive 0.5 to 3.0 change in their post-ALEP mean cluster score. For the non-ALEP instructors (*n* = 9), 11.1% had 0 change in their post-mean cluster score and 77.7% had a positive 0.5 to 3.0 change in their post-mean cluster score. Change in mean cluster score results are reported for the number of people (*n*) and percentages. For ease of reading, frequency percentages have been rounded to the nearest tenth percent.

Table 14

Change in Mean Semester COPUS Cluster Scores for ALEP Instructor Participants and Non-ALEP Instructors from Spring 2018 Pre- to Fall 2018 Post-

ALEP Participants			Non-ALEP Instructors		
Mean Change	*n*	%	Mean Change	*n*	%
-2.0	2	6.3	-2.0	0	0
-1.0	3	9.4	-1.0	0	0
-.5	3	9.4	-.5	1	11.1
.0	8	25.0	.0	1	11.1
.5	4	12.5	.5	1	11.1
1.0	6	18.8	1.0	0	0
1.5	2	6.3	1.5	3	33.3
2.0	2	6.3	2.0	2	22.2
3.0	1	3.1	3.0	1	11.1
Total	31	100.0%	Total	9	100.0%

Research Question 2

Investigative Design

To assist in determining the ALEP's effectiveness in supporting engineering instructors' transition to a more learner-centered pedagogical paradigm, this study's research question two inquired if an ALEP instructor participant's COPUS observation protocol score correlated with his or her TPI score and his or her self-reported use of evidence-based teaching strategies. This research question's purpose was to determine if the ALEP instructor participant's TPI score could be validated using his or her COPUS observation protocol. More simply stated, is the instructor teaching using the strategies he or she claimed to use? This is a congruency test, looking to answer – Is what faculty self-report congruent with what is observed in the classroom? This question's null hypothesis would be – No correlation exists between the ALEP instructor participant's COPUS observation protocol score and his or her TPI score.

Research question two used a one-group pretest-posttest design, including just the treatment group's ALEP instructor participants. In a one-group pretest-posttest design, one already existing, or intact, group is used, with both a pretest and posttest being given to the group (Fraenkel et al., 2015).

Participants

Research question two's sample contained only the study's treatment group. The treatment group included 32 ALEP instructor participants. Inclusion criteria for research question two were ALEP instructor participants, who completed a pre-ALEP TPI prior to Workshop #1, and who taught a course in both the Spring 2018 and Fall 2018 semesters. Of the treatment group's 32 participants, only 31 were used in research question two's sample. One instructor was originally part of the Spring 2018 control group, but then participated in the Summer 2018 ALEP program. As they did not have access to the original ALEP program, they were not included in research question two's sample.

Procedures

Research question two involved only the treatment group in research during the Spring 2018, Fall 2018, and Fall 2019 semesters. Two instruments were used for data collection: (1) the COPUS – a protocol for pre- and post-classroom observations used to monitor the treatment group's adoption of evidence-based teaching strategies into his or her course; and (2) the TPI – given as a pre- and post-measure, used to monitor the treatment group's perception of adoption of evidence-based teaching strategies into his or her course. Spring 2018 served as the pre-ALEP semester using both instruments, Fall 2018 served as the post-ALEP using the COPUS, and Fall 2019 served as the post-ALEP using the TPI. Originally, the TPI was planned as a pre-, post-, post-post-measure, with the pre-ALEP TPI being administered in Spring 2018, the post-ALEP TPI being administered in Fall 2018, and the post-post-ALEP TPI being administered in Fall 2019. The Fall 2018 post-ALEP TPI administration had very limited participation and yielded a small number of responses, so the researcher shifted the TPI to a pre-, post-measure with the Fall 2019 administration becoming the post-. The same two pre-ALEP and two post-ALEP classroom observations conducted using the COPUS observation protocol included in research question one were also used in research question two.

Data collection using the TPI began in the Spring 2018. At the start of January's ALEP Workshop #1, before any faculty development programming was conducted, the instructor participants were read, as well as provided, a study information sheet. See

Appendix I for the Active Learning in Engineering Program Information Sheet. Once the information sheet had been read, any study research-related questions were fielded and answered. Then, each consenting participant completed the TPI online in the questionnaire platform Qualtrics on his or her personal device using a link provided in the ALEP learning management system Blackboard community. The pre-ALEP data collection took about 15 minutes and included participants' online TPI responses. The post-ALEP TPI data collection took place at the start of the Fall 2019 semester. The researcher sent, in early September, individual ALEP instructor participant emails inviting them to complete a post-TPI and providing the Qualtrics link. After the initial email invitation, the researcher sent multiple individual follow-up emails to ALEP instructor participants who had not yet completed the post-TPI, requesting their participation.

Analytical Approach

In research question two's analytical approach, the researcher used both the TPI self-reported teaching practices data and the COPUS classroom observation data. Research question two inquired about an ALEP instructor participant's in-class teaching strategies. From the TPI data collected, the researcher used the Category III – In-class features and activities question, TPI question 9, asking instructors – Fraction of typical class period you spend lecturing (presenting content, deriving mathematical results, presenting a problem solution, …). This is a multiple-choice question with instructors choosing 0-20%, 20-40%, 40-60%, 60-80%, or 80-100%. For analysis purposes, the researcher used the centroid of the percentage range each ALEP instructor participant selected on the TPI. The centroids - 10% for 0-20%, 30% for 20-40%, 50% for 40-60%, 70 for 60-80%, and 90% for 80 to 100% - were treated as ordinal data and used for analysis. Each ALEP instructor participant had a pre-ALEP TPI centroid and a post-TPI centroid. From the COPUS data collected, the researcher used the COPUS Analyzer calculated Instructor Presenting collapsed behavior code percentages. As each ALEP instructor participant had two pre-ALEP and post-ALEP classroom observations, he or she had two pre-ALEP Instructor Presenting percentages and two post-ALEP Instructor Presenting percentages. For analysis purposes, the research used both pre-ALEP and both post-ALEP Instructor Presenting percentages, as well as a pre-ALEP mean Instructor Presenting percentage and a post-ALEP mean Instructor Presenting percentage. All COPUS percentages were treated as continuous data.

SPSS was used to run quantitative statistical analysis based on the research question's methodology. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were run for the data. Because at least one of the variables was ordinal, for which normal data distribution cannot be assumed, non-parametric statistics needed to be used. To inquire if an ALEP instructor participant's COPUS observation protocol score correlated with his or her TPI score and his or her self-reported use of evidence-based teaching strategies, the researcher conducted Spearman rho correlations comparing pre-ALEP TPI and COPUS data (*n* = 29), post-ALEP TPI and COPUS data (*n* = 25), and pre-/post-ALEP TPI and COPUS data (*n* = 31). Table 15 shows the pre- and post-ALEP TPI self-reported percent class time lecture centroid and pre- and post-ALEP COPUS mean Instructor Presenting percentage for each ALEP instructor participant.

Table 15

Pre-/Post-ALEP TPI Percent Lecture Centroid and Pre-/Post-ALEP COPUS Mean Instructor Presenting Percentage for each ALEP Instructor Participant (n = 31)

Instructor Id	Pre-ALEP Centroid	Pre-Mean Inst.Presenting (%)	Post-ALEP Centroid	Post-Mean Inst.Presenting (%)
T1	-	-	50	98
T10	50	8	-	-
T11	50	18	50	52.4
T12	30	38	30	46
T13	50	2	30	48
T14	10	44	-	-
T15	90	86	90	54
T16	90	90	70	94
T17	30	86	50	95
T18	50	60	50	94
T19	10	35	10	62.5
T2	50	8	70	76
T20	90	96	70	68
T21	90	94	90	96
T22	70	92	-	-
T24	90	64	90	90
T25	70	64.2	30	56
T26	90	98	70	86
T27	70	84	50	86
T28	70	62	70	56
T29	70	86	70	84
T3	90	98	90	96
T30	70	92	-	-
T31	50	70	30	76
T32	-	-	70	86
T4	50	88	-	-
T5	30	36	10	92
T6	50	6	30	40.9
T7	30	72	10	44
T8	30	18	-	-
T9	50	58	50	96

Data Analysis

To investigate if there was a statistically significant relationship between ALEP instructor participant’s pre-ALEP TPI score and his/her pre-ALEP COPUS observation score, correlations were computed. The self-reported TPI percent class time lecture centroid is ordinal data. Thus, the nonparametric Spearman rho statistic was computed to examine the intercorrelations of the variables. Table 16 shows that all six pairs of pre-intervention instructor presenting variables were significantly correlated. To address this research question, the relationship between the self-reported TPI percent class time lecture centroid and the observed pre-ALEP COPUS mean Instructor Presenting percentage variables is of most interest. The Spearman rho statistic was calculated, $r(27) = .66$, $p < .001$, which would be considered a large effect size according to Cohen (1988). This statistically significant strong, positive correlation indicates that instructors who self-reported a high pre-ALEP TPI percent class time lecture centroid were likely to also have an observed high pre-ALEP COPUS mean Instructor Presenting percentage and vice versa. Of the 31 ALEP instructor participants included in research question two’s sample, only 29 were included in the pre-intervention analysis. One treatment group instructor did not teach in Spring 2018. This meant they had zero pre-intervention observations. One treatment group instructor only had one Spring 2018 observation, so an average COPUS score could not be calculated for analysis.

Table 16

Intercorrelations, Means, and Standard Deviations for Four Pre-Intervention Instructor Presenting Variables (n = 29)

Variable	*M*	*SD*	1.	2.	3.	4.
1. TPI Pre Lecture % Centroid	57.59	24.74	--	.56**	.62**	.66**
2. Inst Presenting S18 1.1	63.66	34.18	--	--	.70**	.91**
3. Inst Presenting S18 1.2	57.25	34.57	--	--	--	.91**
4. S18 Mean Inst Presenting	60.45	32.24	--	--	--	--

Note. **p* < .01

To investigate if there was a statistically significant relationship between ALEP instructor participant's post-TPI score and his/her post-COPUS observation score, a correlation was computed. The self-reported TPI percent class time lecture centroid is ordinal data. Thus, the nonparametric Spearman rho statistic was computed to examine the intercorrelations of the variables. Table 17 shows that all four pairs of post-intervention instructor presenting variables were significantly correlated. To address this research question, the relationship between the self-reported TPI percent class time lecture centroid and the observed post-ALEP COPUS mean Instructor Presenting percentage variables is of most interest. The Spearman rho statistic was calculated, $r(25) = .40$, $p < .05$, which would be considered a medium or typical effect size according to Cohen (1988). This statistically significant medium, positive correlation indicates that instructors who self-reported a high post-ALEP TPI percent class time lecture centroid were likely to also have an observed high post-ALEP COPUS mean Instructor Presenting percentage and vice versa. Of the 31 ALEP instructor participants include in research question two's sample, only 25 were included in the post-intervention analysis as six did not participate in the post-intervention TPI.

Table 17

Intercorrelations, Means, and Standard Deviations for Four Post-Intervention Instructor Presenting Variables (n = 25)

Variable	*M*	*SD*	1.	2.	3.	4.
1. TPI Post Lecture % Centroid	53.20	25.61	--	.18	.43*	.40*
2. Inst Presenting F18 1.1	74.24	30.07	--	--	.14	.66**
3. Inst Presenting F18 1.2	75.91	25.98	--	--	--	.78**
4. F18 Mean Inst Presenting	75.91	19.90	--	--	--	--

Note. *$p < .05$, **$p < .01$

To investigate if there was a statistically significant relationship between ALEP instructor participant's pre-ALEP TPI score and his/her post-COPUS observation score, a correlation was computed. The self-reported TPI percent class time lecture centroid is ordinal data. Thus, the nonparametric Spearman rho statistic was computed to examine the intercorrelations of the variables. Table 18 shows that all six pairs of pre- and post-intervention instructor presenting variables were significantly correlated. To address this research question, the relationship between the self-reported TPI percent class time lecture centroid and the observed post-ALEP COPUS mean Instructor Presenting percentage variables is of most interest. The Spearman rho statistic was calculated, $r(29) = .34$, $p = .06$, which is a non-statistically significant correlation. Of the 31 ALEP instructor participants include in research question two's sample, all 31 were included in the pre- and post-intervention analysis as each had a pre-ALEP TPI and two post-ALEP COPUS observation protocols.

Table 18

Intercorrelations, Means, and Standard Deviations for Four Pre- and Post-Intervention Instructor Presenting Variables (n = 31)

Variable	*M*	*SD*	1.	2.	3.	4.
1. TPI Pre Lecture % Centroid	59.03	24.68	--	.18	.37*	.34
2. Inst Presenting F18 1.1	74.97	28.94	--	--	.18	.69**
3. Inst Presenting F18 1.2	75.02	24.10	--	--	--	.78**
4. F18 Mean Inst Presenting	74.89	19.15	--	--	--	--

Note. $^{*}p < .05$, $^{**}p < .01$

To answer research question two, there seems to be at least a medium or typical to large positive correlation between an ALEP instructor participant's COPUS observation protocol score and his or her self-reported TPI score within the same time frame, both pre- and post-ALEP.

Research Question 3

Investigative Design

To help determine if an instructor's participation in the ALEP supported him or her transitioning to a more learner-centered pedagogical approach by using more evidence-based teaching strategies, this study's research question three investigated if an ALEP instructor participant's post-ALEP COPUS observation score related to his or her ALEP participation intensity or his or her pre-ALEP COPUS observation score. Does sustained participation lead to change in observational practices? Do we see ALEP participation levels catalyzing desirable teaching practice change? More simply stated, can we predict an instructor's post-ALEP COPUS observation score based on the number of ALEP faculty development offerings he or she participated or his or her pre-ALEP COPUS observation score? This question's null hypothesis would be – No relationship exists between the ALEP instructor participant's post-ALEP COPUS observation score and his or her ALEP participation intensity or his or her pre-ALEP COPUS observation score.

Research question three used a one-group pretest-posttest design, including just the treatment group's ALEP instructor participants. In a one-group pretest-posttest design, one already existing, or intact, group is used, with both a pretest and posttest being given to the group (Fraenkel et al., 2015).

Participants

Research question three's sample contained only the study's treatment group. The treatment group included 32 ALEP instructor participants. Inclusion criteria for research question three were ALEP instructor participants who taught a course in both the Spring 2018 and Fall 2018 semesters. Of the treatment group's 32 participants, only 30 were used in research question three’s sample. One instructor was originally part of the Spring 2018 control group, but then participated in the Summer 2018 ALEP program. As they did not have access to the original ALEP program, they were not included in research question three’s sample. One treatment group instructor did not teach in Spring 2018 but did in Fall 2018. This meant they had zero Spring 2018 observations and two Fall 2018 observations, so the researcher couldn’t use their pre-ALEP COPUS observations required for analysis.

Procedures

Research question three involved only the treatment group in research during the late Fall 2017, Spring 2018, Summer 2018, and Fall 2018 semesters. Two sources were used for data collection: (1) the COPUS – a protocol for pre- and post-ALEP classroom observations used to monitor the treatment group’s adoption of evidence-based teaching strategies into his or her course; and (2) the ALEP instructor participants Program participation intensity score. The same two pre-ALEP and two post-ALEP classroom observations conducted using the COPUS observation protocol included in research question one and two were also used in research question three. An ALEP instructor participant’s Program participation intensity score was determined by using the total number of faculty development offerings the instructor participant attended over Program’s duration. A total of eight Program faculty development offerings were provided: pre-work – a pre-ALEP Qualtrics questionnaire was offered via the Program’s eCampus, including online instructional technology modules (4) housed in the Program’s eCampus Organization; face-to-face workshop sessions (3); Community of Scholars sessions (2); technology training clinics; and one-on-one in-classroom practice teaching sessions. The Program’s prework modules was made available for ALEP instructor participants to begin work on in late Fall 2017 and early Spring 2018. The three face-to-face workshops were offered twice each progressively through the Spring 2018 semester. The two Community of Scholars events were offered as continued dialogue between the face-to-face workshops. The technology training clinics were offered in small group format, with ten or less participants per clinic, in late Spring 2018 and summer 2018. The one-on-one in-classroom practice teaching sessions were offered once Zachary's construction was finished, and the building was turned over to the university in August of 2018.

The ALEP instructor participants were encouraged, but not required, to participate in all Program faculty development offerings. The technology training clinic was the only required component for those teaching in the updated Zachry and was offered college wide. The one-on-one in-classroom practice sessions were also offered college-wide to those teaching in the updated Zachry. Attendance was recorded at each faculty development offering.

Analytical Approach

For research question three's analytical approach, the researched used the COPUS classroom observation data and each ALEP instructor participant's participation intensity score to inquire if an instructor participant's post-ALEP COPUS observation score related to his or her ALEP participation intensity or his or her pre-ALEP COPUS observation score. As each individual instructor participant had two pre-ALEP COPUS observations and two post-ALEP observations, and therefore two pre-ALEP and two post-ALEP COPUS Analyzer reported cluster scores, the researcher treated the COPUS Analyzer reported cluster scores, 1 through 7, as scale data and calculated each instructor participant's pre-ALEP mean cluster score COPUS observation score and post-ALEP mean cluster COPUS observation score. To calculate an ALEP instructor participant's participation intensity score, the researcher treated each faculty development offering's attendance as 1 and calculated a total for each instructor participant's faculty development offerings (*n* = 8) attendance. Participation intensity scores were treated as scale data, 1 to 8.

Regression analysis was used to inquire if an instructor participant's post-ALEP COPUS observation score related to his or her ALEP participation intensity or his or her pre-ALEP COPUS observation score. As only 30 of the 32 treatment group ALEP instructor participants met this question's inclusion criteria, the sample size was underpowered to detect anything but very large effects. The regression was run as exploratory, looking for trends, not statistical significance, due to the small, underpowered sample size. The researcher inquired to see if it was trending that there was an interaction between an ALEP instructor participant's post-ALEP COPUS observation score and his or her ALEP participation intensity or his or her pre-ALEP COPUS observation score. Because of a potential correlation between the two predictor variables, ALEP participation intensity and pre-ALEP COPUS observation score, and mask the ability to detect each individual variable's effect on the post-ALEP COPUS observation score, the researcher wanted to separate them as much as possible due to potential issues with multicollinearity.

To avoid this, the post-ALEP mean cluster COPUS observation score was left as is, but the two predictor variables, ALEP participation intensity and pre-ALEP mean cluster COPUS observation score, were recoded and recalculated as a centered-ALEP participation intensity and a centered-pre-ALEP mean cluster COPUS observation score for each instructor participant. A participation intensity by pre-ALEP mean cluster COPUS observation score interaction term was also calculated. Each instructor participant's centered-ALEP participation intensity score was calculated by first calculating the treatment group's overall mean ALEP participation intensity score and then subtracting the instructor participant's participation intensity score from the overall mean. Each instructor participant's centered pre-ALEP mean cluster COPUS observation score was calculated by first calculating the treatment group's overall mean pre-ALEP mean cluster COPUS observation score and then subtracting the instructor participant's pre-ALEP mean cluster COPUS observation score from the mean. Each instructor participant's interaction term was the product of his or her centered-ALEP participation intensity score and his or her centered-pre-ALEP mean cluster COPUS observation score.

Data Analysis

Multiple regression was conducted to investigate the best prediction of Fall 2018 post-ALEP COPUS scores. The assumption of a normal distribution was met and there was not a high intercorrelation between predictor variables. The means, standard deviations, and intercorrelations can be found in Table 19.

Table 19

Intercorrelations, Means, and Standard Deviations for Fall 2018 Post-ALEP COPUS Scores and Predictor Variables (n = 30)

Variable	*M*	*SD*	1.	2.	3.
F18 Mean Cluster Score	3.13	1.39	.25	.67*	-.04
Predictor Variables					
1. Centered Part Intensity Score	.05	1.76	--	.18	.04
2. Centered S18 Mean Cluster	.00	1.38	--	--	-.23
3. Interaction	.42	2.66			--

Note. *$p < .001$

The beta coefficients are presented in Table 20. An ALEP instructor's participation intensity non-significantly accounted for 6% of the variance in his or her post-ALEP mean COPUS cluster score. The combination of variables to predict an ALEP instructor participant's post-ALEP mean COPUS cluster score from his or her participation intensity and pre-ALEP mean COPUS cluster score was statistically significant, $F(2, 27) = 11.70$, $p < .001$. The R^2 value .464. This indicates that 46% of the variance in an instructor's post-ALEP COPUS cluster score was explained by this model. According to Cohen (1988), this is approaching a much larger than typical effect. Together, participation intensity score and Spring 2018 pre-ALEP COPUS cluster score significantly predict Fall 2018 post-ALEP COPUS cluster score. The combination of variables to predict an ALEP instructor participant's post-ALEP mean COPUS cluster score from his or her participation intensity, pre-ALEP mean COPUS cluster score, and the interaction of these two variables was also statistically significant, $F(3, 26) = 7.85$, $p < .001$. The R^2 value .475. This indicates that 47.5% of the variance in an instructor's post-ALEP COPUS cluster score was explained by this model. According to Cohen (1988), again, this is approaching a much larger than typical effect. Figure 9 shows the three regression models.

To answer research question three, an ALEP instructor participant's participation intensity score and Spring 2018 pre-ALEP COPUS cluster score have a statistically significant large effect on his or her Fall 2018 post-ALEP COPUS cluster score, but the pretest score accounts for most of the variability explained in the post-ALEP COPUS cluster score. Although not statistically significant, the positive interaction indicates that as pretest score increased, posttest scores increased, but this effect was more pronounced as intensity increased.

Table 20

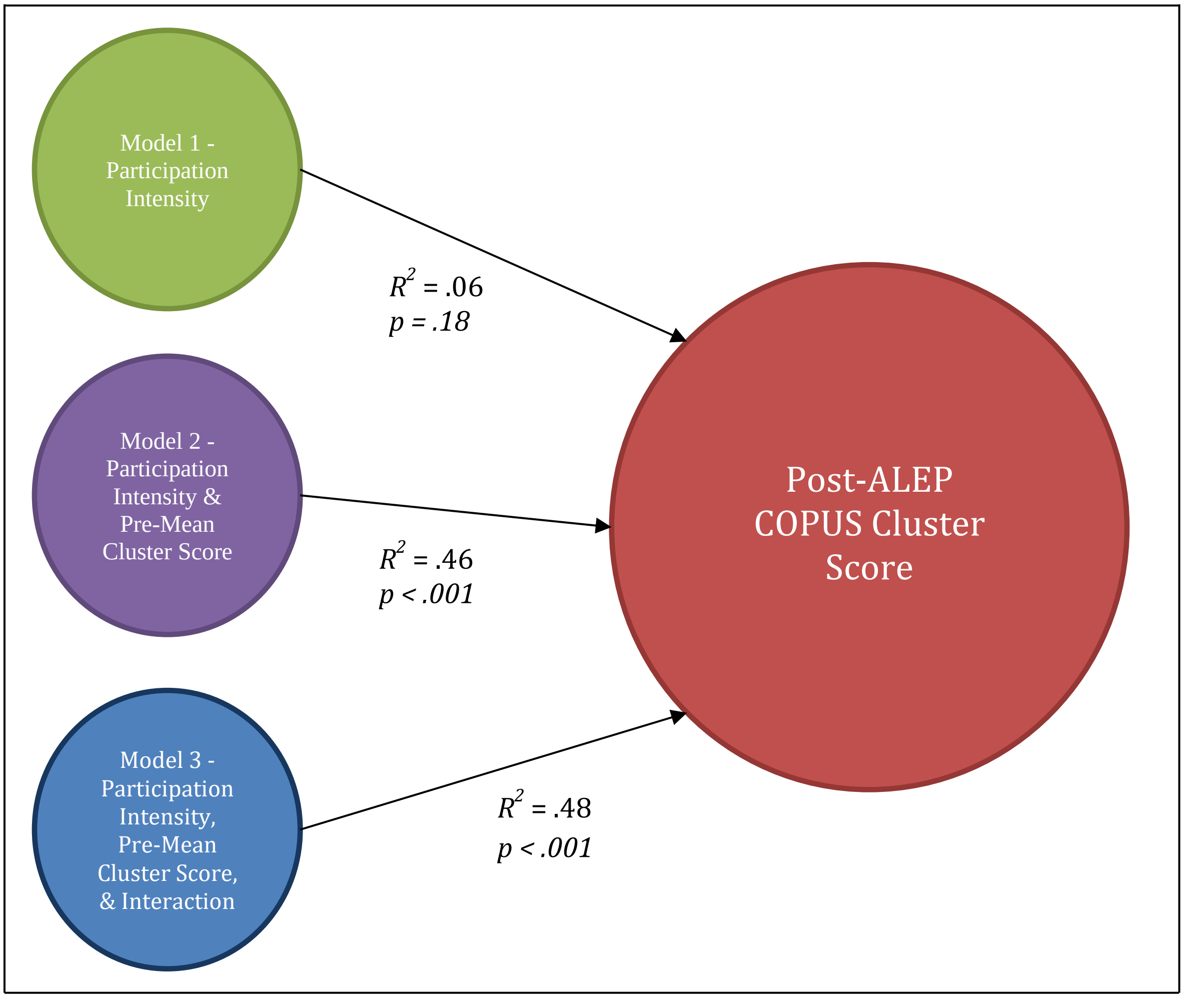
Regression Coefficients for Fall 2018 Post-ALEP COPUS Cluster Scores and Predictor Variables (n = 30)

	Model 1				Model 2				Model 3			
Var.	*B*	*SE*	β	*p*	*B*	*SE*	β	*p*	*B*	*SE*	β	*p*
1	.20	.15	.25	.181	.11	.11	.14	.352	.10	.12	.13	.390
2					.65	.14	.64	<.001	.68	.15	.67	<.001
3									.06	.08	.11	.470
R^2	.063				.464*				.475*			
ΔR^2					.401*				.011*			

Note. Var1: Participation Intensity; Var2: Pre-Mean COPUS Cluster Score; Var3: Interaction *$p < .001$

Figure 9

Regression Models



CHAPTER IV

DISCUSSION AND CONCLUSIONS

Overview of the Problem

Engineering education has a long and well-researched history; however, recent declines in the number of undergraduate students entering and matriculating through to graduation has commanded the attention of the engineering education community (Felder et al., 1998; Seymour & Hewitt, 1997). To help counter the declining number of students entering and persisting in engineering education, as well as address James Duderstadt (1999) rousing call to action, an engineering education reformation is underway where instructors use their engineering mindsets to transition from knowledge transmitters to designers of knowledge creation, learner-centered environments. However, many engineering instructors are not trained in such methodologies. As a result, engineering colleges and departments have made efforts to assist instructors in developing such pedagogical capabilities and efficacy.

In response to a 2012 national call for more engineering graduates, the CoE, in 2013, unveiled its 25x25 initiative (President's Council of Advisors on Science and Technology [PCAST], 2012). To help accomplish its initiative's objectives, the CoE sought to modernize their facilities as a means of supporting pedagogical change, which included innovatively designed learning spaces in the new Zachry. The updated learning spaces catalyzed the need to provide instructors with faculty development to assist their pedagogical transition into the newly renovated Zachry spaces, encouraging them to incorporate more evidence-based teaching strategies as a way of moving towards the College’s 25x25 goals.

Zachry’s modernized learning environment differs greatly from the many more traditional campus learning spaces. Texas A&M’s CoE sought assistance to create a faculty development program to accelerate faculty’s use of the learning spaces Zachry affords. The Active Learning in Engineering Program (ALEP) was developed as a three-way partnership between the CoE, the Center for Teaching Excellence (CTE), and Instructional Technology Services (ITS). The ALEP, anchored in research, initially aimed to prepare and support engineering instructors as they transition pedagogical paradigms into one that foster more learner-centered instruction for the newly designed Zachry. The ALEP aims to: (a) aid engineering instructors in assimilating evidence-based teaching strategies into their existing pedagogical paradigms, and (b) prepare and support all-levels of instructors from diverse engineering departments as they focus on creating a learning environment much different than that many instructors are accustomed. This study evaluated the effectiveness of the ALEP, a program designed to prepare and support engineering instructors transition to a more learner-centered pedagogical paradigm by incorporating evidence-based teaching strategies.

Summary of Findings

There is one overarching finding from this study similar to that of Stains et al. (2018). On average, the didactic instructional profile remains common across undergraduate engineering regardless of the substantial amount of support for more impactful evidence-based teaching strategies. Though this is the case, there appear to be slight differences, slight indicators of improvement that can be detected, while not statistically significant, challenge institutions and disciplines to relook at policies and practices potentially perpetuating this status quo. Specifically, the researcher would recommend institutions reflect on and revise their pre-service and in-service faculty development for future and current instructors, incentivize and reward instructor's implementation of evidence-based teaching practices, and the use of a research-based holistic framework for review of teaching.

Classroom Teaching Strategies Post-ALEP

Instructional Profiles

For the post-ALEP COPUS observations, 84%, or 106 of the total 126, were conducted in the updated Zachry, with 16%, or 20 of the 126, in learning spaces other than those in Zachry. Twenty-six of the 31 ALEP instructor participant's post-ALEP COPUS classroom observations were conducted in the Zachry. Of the 26 treatment group instructors observed in Zachry post-ALEP, 25.8%, or eight of the 31, moved from a fixed-furniture pre-ALEP classroom to a flexible-furniture post-ALEP classroom in Zachry; 61.3%, or 19 of the 31, remained in flexible-furniture classrooms, though their pre-ALEP was not in Zachry. Four post-ALEP COPUS observations were in fixed-furniture learning spaces not in Zachry.

Leveraging the three broad instructional profiles identified by Stains et al. (2018) – didactic style, interactive lecture style, and student-centered style – research question one's results indicated there were no statistically significant differences in the classroom teaching strategies utilized by ALEP instructor participants after participation in the ALEP. Though the treatment group's post-ALEP mean cluster score appears to have increased from their pre-ALEP mean cluster score, it was not a statistically significant difference. Of the 31 ALEP instructor participants with both pre- and post-ALEP mean cluster scores, 25.8%, or eight of the 31, shifted instructor profile types. All eight of the ALEP instructor participants who shifted instructor profiles did so while teaching in Zachry. Table 21 shows the ALEP instructor participants' pre- to post-ALEP change in instructor profile types. Of the eight ALEP instructor participants that shifted instructor profiles, five downshifted, two downshifting from student-centered to interactive lecture style and three downshifting from interactive lecture style to didactic style. Of the eight ALEP instructor participants that shifted instructor profiles, three upshifted, two upshifting from interactive lecture style to student-centered and one upshifting from didactic style to interactive lecture style.

Table 21

Change in Instructor Profile for ALEP Instructor Participants from Spring 2018 Pre- to Fall 2018 Post-

	Pre-ALEP		Post-ALEP		Change
Instructor Profile – Treatment	*n*	%	*n*	%	
Didactic Style	11	35.5	13	41.9	
Interactive Lecture Style	16	51.6	14	45.2	-3, +1
Student-Centered Style	4	12.9	4	12.9	-2, +2
Total	31	100%	31	100%	

With the treatment group's pre-ALEP mean COPUS cluster score of 2.79 as compared to the control group's pre-ALEP mean COPUS cluster score of 1.86, this group of engineering instructors, before participation in the intervention, was already well on their way to collectively having an interactive lecture instructor profile. There is a potential observance of a ceiling effect on the treatment group. A ceiling effect is when "responses on a variable closely approach the maximum possible response so that further increases are difficult to obtain" (Shadish et al., 2002, p. 506). With ALEP offering introductory level instruction on active learning-type evidence-based teaching practices, it would seem this group would have benefitted from a more advanced-level instructional level to see as a comparable change as appeared with the control group. In addition, it could be raised that the study's measurement instrument was not sensitive enough to detect changes. Sensitivity is an instrument's level of accuracy in correctly identifying what is being measured or observed (Mathias, 2012). It may be argued there is a problem in classroom research in that we have a potential measurement issue (Lanahan et al., 2005). Finally, the researcher might infer from this, based on the data analysis, that there was some selection bias in those engineering instructors who chose to participate in the inaugural offering of the ALEP. This may help explain why there was not a statistically significant pre-/post-within group difference after intervention participation, though the post-ALEP mean COPUS cluster score did increase to a 3.09. Though the researcher did not significant differences here, there were slight differences indicating there were slight improvements that could be detected.

Interestingly, as was also reported in research question one's analysis, though lacking the necessary *n* needed for a 0.05 significance level with 80% power, there was a statistically significant increase in the control group's pre-/post-ALEP mean COPUS cluster score. This is the group the researcher is most intrigued by as part of this study. Of the nine control group instructors observed both pre- and post-ALEP, all nine of the non-ALEP instructor's post-ALEP COPUS observations were conducted in the updated

Zachry. Of these nine control group instructors observed in Zachry post-ALEP, 33.3%, or three of the nine, moved from a fixed-furniture pre-ALEP classroom to a flexible-furniture post-ALEP classroom in Zachry; 66.7%, or six of the nine, remained in flexible-furniture classrooms, though their pre-ALEP was not in Zachry.

Leveraging the three broad instructional profiles identified by Stains et al. (2018) – didactic style, interactive lecture style, and student-centered style – research question one's results indicated there were statistically significant within group differences in the classroom teaching strategies utilized by non-ALEP instructors. Of the nine non-ALEP instructors with both pre-and post-ALEP mean cluster scores, 55.6%, or 5 of 9, shifted instructor profile types. Again, all five of the non-ALEP instructors who shifted instructor profiles did so while teaching in Zachry. Table 22 shows the non-ALEP instructors' pre- to post-ALEP change in instructor profile types. Of the five non-ALEP instructors that shifted instructor profiles, one downshifted from interactive lecture style to didactic style. Of the five non-ALEP instructors that shifted instructor profiles, four upshifted, one upshifting from interactive lecture style to student-centered and three upshifting from didactic style to interactive lecture style.

Table 22

Change in Instructor Profile for Non-ALEP Instructors from Spring 2018 Pre- to Fall 2018 Post-

	Pre-ALEP		Post-ALEP		Change
Instructor Profile – Control	*n*	%	*n*	%	
Didactic Style	5	55.6	3	33.3	
Interactive Lecture Style	4	44.4	5	55.6	-1, +3
Student-Centered Style	0	0.0	1	11.1	-0, +1
Total	9	100%	9	100%	

With this subset of the control group's pre-ALEP mean COPUS cluster score increasing from 2.00 before teaching in the Zachry to a post-ALEP mean COPUS cluster score of 3.28 upon teaching in the Zachry, this group of engineering instructors shifted as a collective whole from a didactic instructional profile to an interactive lecture instructor profile on their own accord. The researcher might infer from this, based on the data analysis, that there is some natural adaption to the new teaching environment, even without formal pedagogical training. This could also be explained by an environmental effect, the result of an environmental change when these instructors moved into teaching in the new Zachry. While several had already been previously teaching in a flexible classroom space, none were as technologically rich or arranged quite like those in the redesigned Zachry. Lastly, another plausible explanation for the significant increase in the non-ALEP instructors' post-mean COPUS cluster score could be due to the Hawthorne effect, in that the positive effect, the positive alteration in instructional practices is due to increased attention and their awareness of being observed (Fraenkel et al., 2015).

The researcher is aware, as has been seen in previous research (Lund et al., 2015), there is variability in the day-to-day classroom instructional practices used by individual instructors. This study took just two snapshots in time. Stains et al.'s (2018) data suggested that at least four instructor-specific classroom observations are required for a reliable teaching characterization to be made. With this study only conducting two classroom observations, the findings are not generalizable to a larger population.

Common COPUS Instructor Behaviors

The researcher compared Stains et al.'s (2018) reported top common COPUS instructor behaviors (*n* = 2008 COPUS protocols) with this study's top common pre-ALEP (*n* = 115 COPUS protocols) and top common post-ALEP COPUS instructor behaviors (*n* = 126 COPUS protocols). Table 23 shows the three most common COPUS instructor behaviors reported for all Stains et al. (2018), as well as pre-ALEP and post-ALEP instructor participants and non-ALEP instructors.

Table 23

Three Most Common COPUS Instructor Behaviors Reported for Stains et al. (2018) and Pre-ALEP and Post-ALEP for All Instructor Participants, ALEP Instructor Participants, Non-ALEP Instructors

	All Instructor Participants		ALEP Instructors		Non-ALEP Instructors	
Stains et al. (2018) Instructor Codes (*n* = 2008 COPUS protocols)	%	SD				
Lecture	74.9	27.8				
Writing in real time	35.0	35.2				
Non-rhetorical questions	25.0	21.4				
Pre-COPUS Instructor Codes (*n* = 115 COPUS protocols)	%	SD	%	SD	%	SD
Lecture	61.8	32.1	52.5	35.0	72.4	24.8
Writing in real time	58.4	31.8	52.3	33.7	65.2	28.2
Non-rhetorical questions	29.0	18.8	28.1	20.0	30.0	17.8
Post-COPUS Instructor Codes (*n* = 126 COPUS protocols)						
Writing in real time	78.9	26.1	72.8	27.5	86.0	22.5
Lecture	58.4	30.0	52.0	31.5	65.9	26.5
Non-rhetorical questions	32.7	24.5	36.1	26.4	29.8	21.6

The same three instructor behaviors – lecture, writing in real time, and posing non-clicker/non-rhetorical questions – appear in the top three and in the same order but the post-ALEP time period in which writing in real time is the overall most common instructor behavior. For both the overall pre-ALEP and post-ALEP classroom observations, the average percent of the total 2-minute COPUS intervals of a 50-minute class observation spent lecturing was lower than Stains et al., with the pre-ALEP lecture percentage being 13.1% lower and the post-ALEP lecture percentage being 16.5% lower. For both the overall pre-ALEP and post-ALEP classroom observations, the average percent of the total 2-minute COPUS intervals of a 50-minute class observation spent writing in real time was higher than Stains et al., with the pre-ALEP posing writing in real time percentage being 23.4% higher and the post-ALEP writing in real time percentage being 43.9% higher. For both the overall pre-ALEP and post-ALEP classroom observations, the average percent of the total 2-minute COPUS intervals of a 50-minute class observation spent posing non-clicker/non-rhetorical questions was higher than Stains et al., with the pre-ALEP posing non-clicker/non-rhetorical questions percentage being 4.0% higher and the post-ALEP posing non-clicker/non-rhetorical questions percentage being 7.7% higher.

The researcher infers, based on the data analysis, that the lower lecture percentages and higher writing in real time and posing non-clicker/non-rhetorical questions percentages seem to align with a more cognitive-apprenticeship type approach to teaching post-ALEP in Zachry. Zachry provides a physical learning environment that is geared for a cognitive-apprenticeship approach where instructors, the disciplinary experts, make the learning explicit for students, who learn as apprentices through observation, imitation, and modeling (Collins et al., 1987). The learning spaces are designed to become learning environments and the instruction shifted to build a community with instruction transitioning from transactional or transmission sites to knowledge sharing and knowledge creation communities.

Faculty Development

The ALEP focuses on a posterior issue. If faculty are going to be educators, it is beneficial they participate in pedagogical faculty development before beginning teaching. This is not universal across all graduate programs. Once faculty begin their educator role, pedagogical training gets added to their over-burgeoning action items list. From this point, the only thing available to them is in-service pedagogical-focused faculty development. That in-and-of-itself is limiting for a multitude of reasons, one being it is not incentivized. It takes an institutional change, not just a faculty change, to help provide the time and support to prioritize. Part of the suggested institutional change, in addition to incentivizing faculty development, is to help balance this posterior issue with an a priori approach to build in the nurturing and the retention of an instructor's faculty development in the early years. The impact of early instruction, early intervention helps to instill and reinforce the embedding of evidence-based teaching practices from the start.

This study's research question two's data analysis indicates that there seems to be at least a medium or typical to large positive correlation between an ALEP instructor participant's COPUS observation protocol score and his or her self-reported TPI score within the same time frame, both pre- and post-ALEP. This finding indicates that the ALEP instructor participants quite accurately reported on their TPI what the researcher and trained observers observed in the classroom. This study's research question three's data analysis included an ALEP instructor participant's participation intensity score and Spring 2018 pre-ALEP COPUS cluster score have a statistically significant large effect on his or her Fall 2018 post-ALEP COPUS cluster score. From these two findings, the researcher concludes that an instructors current teaching practices and his or her participation intensity in faculty development have a significant impact on future teaching practices, thus solidifying the need for an instructor's faculty development in the early years, as well as sustained throughout his or her time in teaching.

Subsequent ALEP Iterations

Since this study's initial offering of the ALEP, additional ALEP iterations have been offered to interested engineering instructors. These additional iterations were refined and revised for improvement purposes based on reflective assessment and feedback from participants, as well as the collaborative project management team facilitating the Program. One salient change the project management team made was to shorten the time between workshops, striving to offer a more concentrated faculty development experience for the participating engineering instructors. Another change made was the Program's scaffolding. Participant reflection time and implementation planning was strategically built in to afford busy instructors time to think how he or she planned to incorporate the evidence-based teaching strategies the ALEP was recommending. With a tighter turnaround between workshops, the project management team could encourage instructor participants to try at least one evidence-based teaching strategy between workshops and then share how it went in the subsequent workshop. This propagation method, versus a best practices dissemination method, was intentionally used to meaningfully and frequently connect with the instructor participants, interactively inviting them to take an instructional mindset to create a strong implementation plan. Our project management team aimed to prepare instructors, build community, promote evidence-based teaching, and create instructor leaders as they help to bring about individual and/or organizational change (Morrone et al., 2017). Finally, though the TPI and COPUS research components were valuable to assessing the ALEP's effectiveness, the research components were not sustainable beyond the inaugural iteration.

Directions for Future Research

What is void from this study is the instructor’s voice in all of this. This study represents only a start, a germination, but there is significant room for a qualitative inquiry perspective, inviting instructors into the faculty development conversation. This study is completely devoid of the instructor’s voice in their introspective reflections on such matters and potential implementation and faculty development solutions. I would appreciate the opportunity to conduct semi-structed interviews and/or focus groups to explore such instructor-focused questions as: (1) What did you find most beneficial about your ALEP experience?, (2) What would have made your ALEP experience more impactful?, (3) Are there additional resources the ALEP could have provided to assist in shifting pedagogical paradigms?, (4) What do you perceive as the role and/or value being more innovative in your teaching?, (5) Why did you or why did you not adopt evidence-based teaching strategies?, and (6) What classroom implementation barriers do you perceive? This study serves a meaningful purpose – to allow the researcher to realize what we know, what we still don’t know, everything that we didn't do, and everything we hope to yet do. It's valuable.

Future research includes bringing in community of practice literature (Wenger, 1999) and situated learning theory (Lave et al., 1991) to intentionally create a sustained faculty development offering propagating the use of evidence-based teaching strategies and the assessment of their impact on student learning. Texas A&M’s Institute of Engineering Education and Innovation (IEEI) has formed an engineering education group; I think this is a meaningful step to helping these faculty who are interested in doing classroom research feel supported and connected in their efforts. Bridging those who may not be familiar with human subject research with social scientists I think is way to help further this valuable research area into what brings about significant gains in student learning.

Another area for future research is to help bring about lasting pedagogical change through challenging instructor's conceptualizations of learning (Donaldson & Allen-Handy, 2020). Learning scientists have determined our practices grow out of our conceptualization. So, forming communities to challenge instructor's conceptualizations, read through and grapple with relevant literature, and develop a foundational understanding of how learning works from a student-centered lens. These communities would support instructors as they create a cognitive apprenticeship opportunity within their classrooms. Also, as part of these community's charge would be the development of instructor leaders to then mentor others and continue this work on a larger scale.

Future research I would like to explore is rethinking participation intensity scoring, calibrating an event's point value, similar to the TPI, based on its impact on student learning as shown in research. Some events would remain scored as one point, but some events would be scored two or even three points. This would potentially bring more accuracy and nuance in the participation intensity measures sensitivity. For example, online modules are meaningful, but they may not be as impactful to student learning as a practice teaching session in the classroom. So, weighting these events differently may more accurately reveal participation intensity having an association with post-COPUS observations.

Finally, one more area for future research is looking at the benefits from studies that examine the effect of the instructional innovations on students and their learning. This student focused solely on the instructor aspect but broadening the scope of research to include the student learning piece is key to helping link instructional innovation to student learning. Instructional innovation for innovation’s sake is not the salient reason for such endeavors but linking that innovation to its impact on student learning is key for furthering the work we do in faculty development.

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APPENDIX A

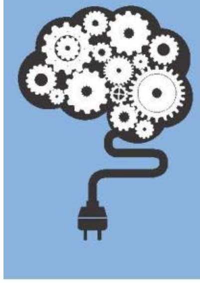
ACTIVE LEARNING IN ENGINEERING PROGRAM – ACTIVE LEARNING ONE-PAGER

“Active Learning One-Pager”, 2018, created by Samantha Shields, Center for Teaching Excellence, Texas A&M University, is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

TEACHING
FOR
LEARNING

Active Learning

[ak-tiv + lur-ning]



Active learning is anything course-related that all students in a class session are **called upon to do** other than simply watching a lecture and taking notes.[1]

- Felder and Brent (2016)

Active learning is generally defined as any instructional method that **engages students in the learning process**...The core elements of active learning are student activity and engagement in the learning process.[2]

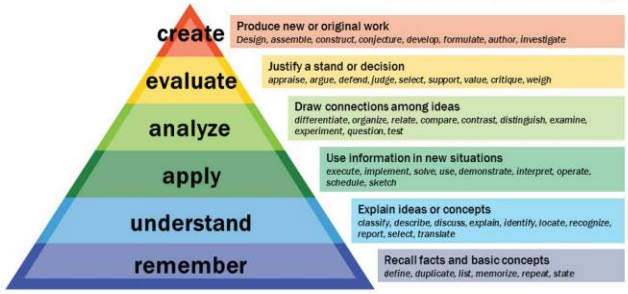
- Prince (2004)

...those [methods] designed at least in part to promote conceptual understanding through interactive engagement of students in **heads-on (always)** and hands-on (usually) activities..." [3]

- Hake (1998)

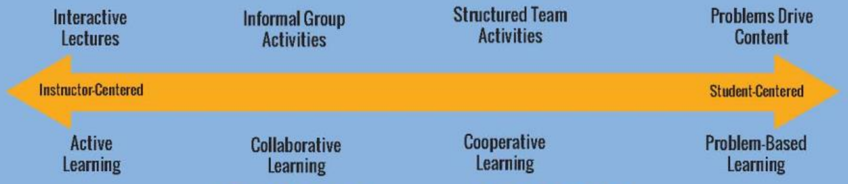
Active learning is AN APPROACH that advances instruction up Bloom's Taxonomy for deeper, more critical student thinking with classrooms transitioning emphasis from knowledge transmission to knowledge creation.

Bloom's Taxonomy



Vanderbilt University Center for Teaching [4]

Active learning strategies vary widely, but can be categorized into four broad types that span the continuum of those more instructor-centered to those more student-centered.



Interactive Lectures | Informal Group Activities | Structured Team Activities | Problems Drive Content

Instructor-Centered ⟷ Student-Centered

Active Learning | Collaborative Learning | Cooperative Learning | Problem-Based Learning

Active learning strategies to consider incorporating![1, 5, 13]

- The Pause Approach
- Think-Pair-Share
- Entry/Exit Tickets
- One-Minute Paper
- Concept Maps
- Case Study
- Debate
- Role Play
- Perform a Demonstration
- Muddiest Point
- Jigsaw Method
- Guided Notes
- Chunked Problem Analysis
- Thinking-Aloud Pair Problem Solving
- Personal Response Cards/Systems

Why Bother?

Student attention spans are about 15 minutes during lecture. After that point, student attention decreases rapidly, as does their retention of information presented in the lecture.[6, 7]

In studies where active learning was the treatment and lecture was the control - "If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit-"[8]

Active learning has been proven to be twice as effective as lecturing.[3]

Getting Started with Active Learning[9, 10, 11, 12]

1. Start small! Ease into using active learning strategies. Look for low stakes ideas to start with and keep it short!
2. Take time to learn about and practice a strategy before using it in class. Find one that's comfortable for you!
3. Explain to your students upfront what you're doing, why, and how it will benefit their learning...thinking about thinking (metacognition)! Sell it!!!
4. Consider your course objectives when choosing an active learning strategy. Make sure it aligns with the course and is both purposeful and meaningful to student learning.
5. Model, practice, and explain your expectations for any new active learning strategy you use in class.
6. Strive to build solid relationships with your students early and often. Take time to interact with them while they are participating in the active learning activity.
7. Reflect after each use and continue to refine your use of an active learning strategy...KEEP TRYING! Ask students for input and feedback on the use the strategy as well.
8. Move content to be memorized and content that is nice-to-know outside of class. Save class time for the bottleneck or roadblock areas where students struggle.

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APPENDIX B

TEACHING PRACTICES INVENTORY (TPI)

“CSWEI Teaching Practices Inventory” by Carl Wieman Science Education Initiative at the University of British Columbia is licensed under Attribution-NonCommercial 3.0 Unported License https://creativecommons.org/licenses/by-nc/3.0/. Available at http://www.cwsei.ubc.ca/resources/TeachingPracticesInventory.htm.

CWSEI Teaching Practices Inventory

To create the inventory we devised a list of the various types of teaching practices that are commonly mentioned in the literature. We recognize that these practices are not applicable to every course, and any particular course would likely use only a subset of these practices.

We have added places that you can make additions and comments and we welcome your feedback.

It should take only about 10 minutes to fill out this inventory.

Please fill out the inventory for the current Term, Lecture sections only.

Course number: ________________________________
Section #(s) or Instructor name: ________________________________
Total number of students in sections you taught (approximate): ________________________________

I. Course information provided to students via hard copy or course webpage. (check all that occurred in your course)

- ☐ List of topics to be covered
- ☐ List of topic-specific competencies (skills, expertise, …) students should achieve (what students should be able to *do*)
- ☐ List of competencies that are not topic related (critical thinking, problem solving, …)
- ☐ Affective goals – changing students' attitudes and beliefs (interest, motivation, relevance, beliefs about their competencies, how to master the material)
- ☐ Other (please specify)

If you selected other, please specify ____

II. Supporting materials provided to students (check all that occurred in your course)

- ☐ Student wikis or discussion boards with little or no contribution from you.
- ☐ Student wikis or discussion boards with significant contribution from you or TA.
- ☐ Solutions to homework assignments
- ☐ Worked examples (text, pencast, or other format)
- ☐ Practice or previous year's exams
- ☐ Animations, video clips, or simulations related to course material
- ☐ Lecture notes or course Powerpoint presentations (partial/skeletal or complete)
- ☐ Other instructor selected notes or supporting materials, pencasts, etc.
- ☐ Articles from scientific literature
- ☐ Other (please specify)

If you selected other, please specify ____

III. In-class features and activities

A. Various

Give approximate average number:

Average number of times per class: pause to ask for questions ___________________________________

Average number of times per class: have small group discussions or problem solving ___________________________________

Average number of times per class: show demonstrations, simulations, or video clips ___________________________________

Average number of times per class: show demonstrations, simulations, or video where students first record predicted behavior and then afterwards explicitly compare observations with predictions ___________________________________

Average number of discussions per term on why material useful and/or interesting from students' perspective ___________________________________

Comments on above (if any): ____________ ____

____

Check all that occurred in your course:

- ☐ Students asked to read/view material on upcoming class session
- ☐ Students read/view material on upcoming class session and complete assignments or quizzes on it shortly before class or at beginning of class
- ☐ Reflective activity at end of class, e.g. "one minute paper" or similar (students briefly answering questions, reflecting on lecture and/or their learning, etc.)
- ☐ Student presentations (verbal or poster)

Fraction of typical class period you spend lecturing (presenting content, deriving mathematical results, presenting a problem solution, ...)

- ○ 0-20%
- ○ 20-40%
- ○ 40-60%
- ○ 60-80%
- ○ 80-100%

Considering the time spent on the major topics, approximately what fraction was spent on the *process* by which the theory/model/concept was developed?

- ○ 0-10%
- ○ 11-25%
- ○ more than 25%

B. Personal Response System (PRS)

If a student response system is used to collect responses from all students IN REAL TIME IN CLASS, what method is used? (check all that occurred in your course)

- ☐ electronic ("clickers") with student identifier
- ☐ electronic anonymous
- ☐ colored cards
- ☐ raising hands
- ☐ written student responses that are collected and reviewed in real time
- ☐ Other (please specify)

If you selected other, please specify ____

Number of PRS questions posed followed by student-student discussion per class ____

Number of times PRS used as quiz device (counts for marks and no student discussion) per class ____

IV. Assignments (check all that occurred in your course)

- ☐ Problem sets/homework assigned or suggested but did not contribute to course grade
- ☐ Problem sets/homework assigned and contributed to course grade at intervals of 2 weeks or less
- ☐ Paper or project (an assignment taking longer than two weeks and involving some degree of student control in choice of topic or design)
- ☐ Encouragement and facilitation for students to work collaboratively on their assignments
- ☐ Explicit group assignments
- ☐ Other (please specify)

If you selected other, please specify ____

V. Feedback and testing; including grading policies (check all that occurred in your course)

A. Feedback from students to instructor during the term

- ☐ Midterm course evaluation
- ☐ Repeated online or paper feedback or via some other collection means such as clickers
- ☐ Other (please specify)

If you selected other, please specify ____

B. Feedback to students (check all that occurred in your course)

- ☐ Assignments with feedback before grading or with opportunity to redo work to improve grade
- ☐ Students see graded assignments
- ☐ Students see assignment answer key and/or grading rubric
- ☐ Students see graded midterm exam(s)
- ☐ Students see midterm exam(s) answer key(s)
- ☐ Students explicitly encouraged to meet individually with you
- ☐ Other (please specify)

If you selected other, please specify ____

<u>C. Testing and grading</u>

Number of midterm exams ________________________________

Approximate fraction of exam mark from questions that required students to explain reasoning ________________________________%

Approximate breakdown of course mark (% in each of the following categories)

Final Exam	________________________________%
Midterm Exam(s)	________________________________%
Homework assignments	________________________________%
Paper(s) or project(s)	________________________________%
In-class activities	________________________________%
In-class quizzes	________________________________%
Online quizzes	________________________________%
Participation	________________________________%
Lab component	________________________________%
Other	________________________________%
If you selected other, please specify:	________________________________

VI. Other (check all that occurred in your course)

☐ Assessment given at beginning of course to assess background knowledge
☐ Use of instructor-independent pre-post test (e.g. concept inventory) to measure learning
☐ Use of a consistent measure of learning that is repeated in multiple offerings of the course to compare learning
☐ Use of pre-post survey of student interest and/or perceptions about the subject
☐ Opportunities for students' self-evaluation of learning
☐ Students provided with opportunities to have some control over their learning, such as choice of topics for course, paper, or project, choice of assessment methods, etc.
☐ New teaching methods or materials were tried along with measurements to determine their impact on student learning

VII. Training and guidance of Teaching Assistants (check all that occurred in your course)

☐ No TAs for course
☐ TAs must satisfy English language skills criteria
☐ TAs receive ½ day or more of training in teaching
☐ There are Instructor-TA meetings every two weeks or more frequently where student learning and difficulties, and the teaching of upcoming material are discussed.
☐ TAs are undergraduates
☐ TAs are graduate students
☐ Other (please specify)

If you selected other, please specify ____

VIII. Collaboration or sharing in teaching

☐ Used or adapted materials provided by colleague(s)
☐ Used "Departmental" course materials that all instructors of this course are expected to use

Discussed how to teach the course with colleague(s)

○ 1 Never
○ 2
○ 3
○ 4
○ 5 Very Frequently

Read literature about teaching and learning relevant to this course

○ 1 Never
○ 2
○ 3
○ 4
○ 5 Very Frequently

Sat in on colleague's class (any class) to get/share ideas for teaching

○ 1 Never
○ 2
○ 3
○ 4
○ 5 Very Frequently

IX. General (open-ended comments)

Please write any other comments here. If this inventory has not captured an important aspect of your teaching of this course, or you feel you need to explain any of your above answers please describe it here.

____
____
____

Approximately how long did it take you to fill out this inventory? ________________

We thank you for taking the time to fill out this inventory.

APPENDIX C

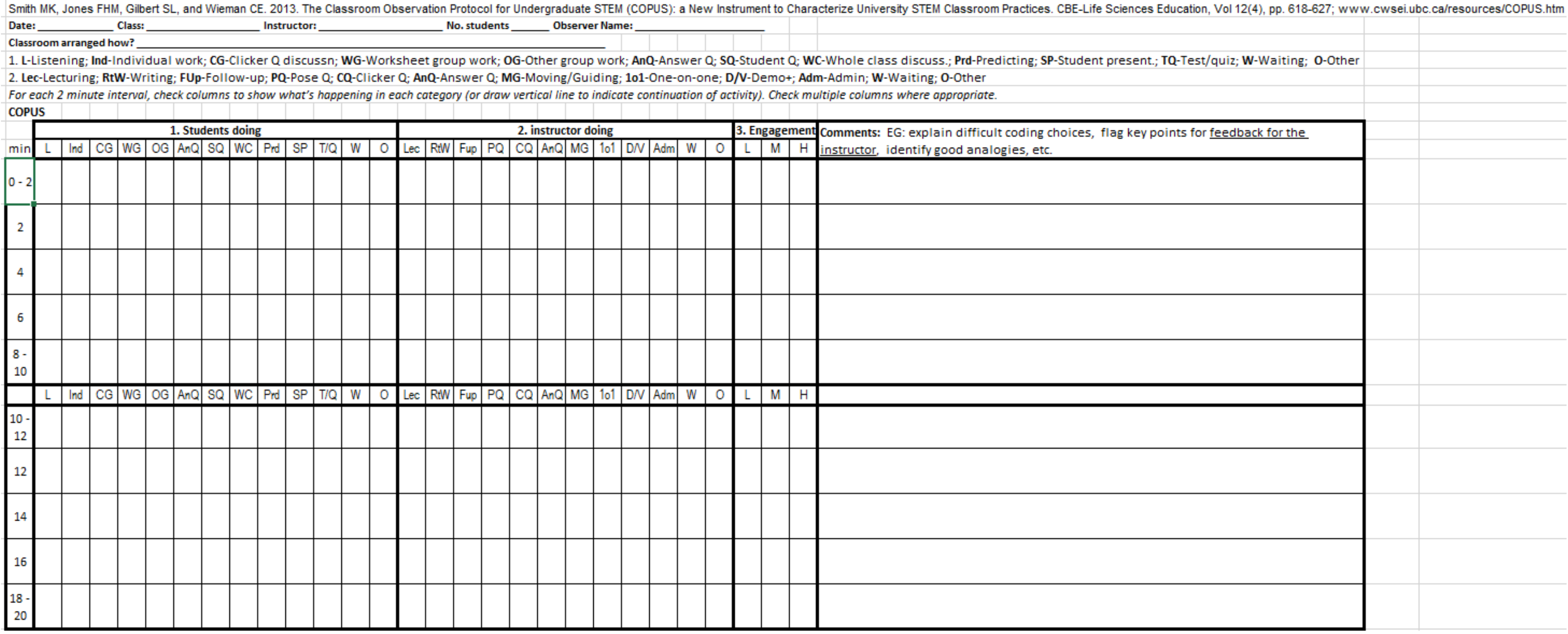
TEACHING PRACTICE INVENTORY – SCORING RUBRIC EXAMPLE

Table S1 (corrected). Category scores for the 31 courses in one department.

Course #	I. Course info	II. Supporting materials	III. In class activities	IV. Assignments	V. Feedback & testing	VI. Other (diagnostics, ...)	VII. TA Training & Guidance	VIII. Collaboration	ETP total score
1	5	4	13	6	7	4	1	3	43
2	2	4	7	5	11	2	3	5	39
3	6	5	11	3	9	6	3	3	46
4	2	4	7	5	11	2	3	5	39
5	4	5	8	3	8	3	3	1	35
6	4	4	9	4	6	3	3	5	38
7	2	6	4	4	6	1	2	1	26
8	5	6	6	4	8	1	3	3	36
9	4	5	1	3	8	1	0	3	25
10	4	5	3	3	9	0	2	2	28
11	4	4	3	4	7	1	0	5	28
12	0	1	2	2	2	1	0	2	10
13	4	3	9	2	6	4	4	3	35
14	4	4	7	4	9	0	4	1	33
15	5	6	8	0	8	0	2	5	34
16	4	5	9	0	8	1	3	2	32
17	3	2	3	1	6	0	3	4	22
18	4	5	5	3	8	0	3	1	29
19	1	4	4	2	7	0	0	0	18
20	4	5	6	3	8	2	2	2	32
21	1	4	0	2	9	1	2	0	19
22	6	6	12	4	11	1	2	4	46
23	5	5	10	2	9	3	2	2	38
24	6	4	4	2	9	3	2	2	32
25	5	4	4	6	9	0	4	3	35
26	4	6	8	4	10	1	3	5	41
27	1	5	4	4	10	0	0	4	28
28	4	4	4	6	9	3	4	3	37
29	6	5	9	6	9	4	4	5	48
30	4	4	4	4	9	0	2	2	29
31	2	6	6	2	6	2	2	4	30
Max possible	6	7	15	6	13	10	4	6	67

APPENDIX D

CLASSROOM OBSERVATION PROTOCOL FOR UNDERGRADUATE STEM (COPUS)



Smith MK, Jones FHM, Gilbert SL, and Wieman CE. 2013. The Classroom Observation Protocol for Undergraduate STEM (COPUS): a New Instrument to Characterize University STEM Classroom Practices. CBE-Life Sciences Education, Vol 12(4), pp. 618-627; www.cwsei.ubc.ca/resources/COPUS.htm

Date: ____________ **Class:** _________________ **Instructor:** ___________________ **No. students** ______ **Observer Name:** ____________________

Classroom arranged how? ____

1. **L**-Listening; **Ind**-Individual work; **CG**-Clicker Q discussn; **WG**-Worksheet group work; **OG**-Other group work; **AnQ**-Answer Q; **SQ**-Student Q; **WC**-Whole class discuss.; **Prd**-Predicting; **SP**-Student present.; **TQ**-Test/quiz; **W**-Waiting; **O**-Other

2. **Lec**-Lecturing; **RtW**-Writing; **FUp**-Follow-up; **PQ**-Pose Q; **CQ**-Clicker Q; **AnQ**-Answer Q; **MG**-Moving/Guiding; **1o1**-One-on-one; **D/V**-Demo+; **Adm**-Admin; **W**-Waiting; **O**-Other

For each 2 minute interval, check columns to show what’s happening in each category (or draw vertical line to indicate continuation of activity). Check multiple columns where appropriate.

COPUS

	1. Students doing													**2. instructor doing**												**3. Engagement**			**Comments:** EG: explain difficult coding choices, flag key points for feedback for the instructor, identify good analogies, etc.
min	L	Ind	CG	WG	OG	AnQ	SQ	WC	Prd	SP	T/Q	W	O	Lec	RtW	Fup	PQ	CQ	AnQ	MG	1o1	D/V	Adm	W	O	L	M	H	
0 - 2																													
2																													
4																													
6																													
8 - 10																													
	L	Ind	CG	WG	OG	AnQ	SQ	WC	Prd	SP	T/Q	W	O	Lec	RtW	Fup	PQ	CQ	AnQ	MG	1o1	D/V	Adm	W	O	L	M	H	
10 - 12																													
12																													
14																													
16																													
18 - 20																													

APPENDIX E

CLASSROOM OBSERVATION PROTOCAL FOR UDNDERGRADUATE STEM (COPUS) TRAINING GUIDE

Smith MK, Jones FHM, Gilbert SL, and Wieman CE. 2013. The Classroom Observation Protocol for Undergraduate STEM (COPUS): a New Instrument to Characterize University STEM Classroom Practices. CBE-Life Sciences Education, Vol 12(4), pp. 618-627; www.cwsei.ubc.ca/resources/COPUS.htm

COPUS Training Guide

1. [10 mins.] Introductions and brief rationale for exercise and overall goals.

2. [15 mins.] Hand out paper copies of protocol and code explanations. Allow participants to read them over. Project the code explanations. Discuss the codes as a group and answer any questions.

3. [5–10 mins.] Show two minutes of a video that is straightforward to code (mostly lecture, administrative announcements). Observers individually mark their paper copy of the protocol. Stop after two minutes and have a group discussion about the codes they selected. Which codes chosen for students? For instructor? How many for each?

4. [8 mins.] Now group the observers in pairs and have the two observers sit near each other. Play a video for ~8 minutes and have observers record what is going on in 2- minute segments on the paper copy of the protocol. In order to keep all observers in sync, use either a shared two-minute sand timer or a stopwatch counting up (this feature is often found on cell phones).

5. [10 mins.] Have the observer pairs first compare notes with each other for the 8- minute segment and then have a discussion with the larger group. For the group discussion, observers take turns volunteering what they coded for the students and the instructors every two minutes for the 8-minute clip. Discuss any codes that were unclear. For example, observers often want to clarify when to mark the student code "OG Other group activity" and how that differs from having students discuss a clicker question or work on a worksheet. It is also recommended to discuss the instructor code "FUp Follow up" and the importance of marking "PQ Posing non-clicker question to students" if the instructor follows up by posing questions to students. Observers may also talk about the relationship between some student and instructor codes. For example, if observers mark "CG students discussing a clicker question," they will also likely mark the instructor code "CQ Asking a clicker question."

6. [15 mins.] Have observer pairs code two minutes of a video segment that shows students and instructors showing multiple behaviors such as asking and answering questions, small group activities, and/or discussing clicker questions. After two- minutes have the pairs compare codes and discuss the results with the larger group. Then have observers code the next 6 minutes (8 minutes total of this segment of the class). Again have pairs compare answers and discuss the answers as a whole group volunteering what they coded for the students and the instructors every two minutes for the 8-minute clip.

7. [10 mins.] Organize pairs and select classes to observe. Plan a way to collect data from observers (collect paper copies, fill in the information on an on line form). If possible, meet with observers after they have collected data to share aggregate results and talk through any codes that were causing difficulties.

8. If you have two observers in a classroom and would like to calculate inter-rater reliability (IRR), for all 25 codes add up all the total number of times: 1) both observers put a check in the same box, 2) neither observer put a check in the same box, 3) observer 1 put a check in a box when observer 2 did not, and 4) observer 2 put a check in a box when observer 1 did not. With this information, you can use a statistical package such as SPSS (IBM Inc.) to calculate the Kappa values.

Video resources that may be helpful for COPUS training:

Description of video	URL
Demonstration, clicker questions, and lecture	http://harvardmagazine.com/2012/02/interactive-teaching
Group activities and lecture	http://podcasting.gcsu.edu/4DCGI/Podcasting/UGA/Episodes/12746/614158822.mov
Clicker questions and lecture	http://podcasting.gcsu.edu/4DCGI/Podcasting/UGA/Episodes/22253/27757327.mov
Clicker, real-time writing, and lecture	http://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2008/video-lectures/lecture-19/
Real-time writing, asking/answering questions, lecture	http://ocw.mit.edu/courses/biology/7-012-introduction-to-biology-fall-2004/video-lectures/lecture-6-genetics-1/

APPENDIX F

CLASSROOM OBSERVATION PROTOCAL FOR UNDERGRADUATE STEM (COPUS) RESEARCHER'S SUPPLEMENTAL OBSERVATION PREPARATION GUIDE

To begin an observation:

1. Open the Observation Items folder nested inside the COPUS folder – O:\CTE\General\Programming\Engineering\Active Learning in Engr (ALEP)\COPUS\Observation Items

2. Inside the folder, I plan to have already pre-created the observation spreadsheet for you. Open the embedded Fall 2018 folder, search for the last initial of the person you are observing, followed by the course you observing, followed by the date. Open the spreadsheet and you should be ready to start observing…skip to step #4.

   If there is not one, back out of the Fall 2018 folder and open the COPUS with TA spreadsheet. Do a Save As and save it in the Fall 2018 folder using the following format: AM - ENGR 482 - 4.5.18 (last initial first initial – course – date)

3. Once you have saved your spreadsheet, please complete the basic observation information. Put your cursor in cell A2. Cell A2 will allow you to input the:
    a. Date (e.g., 8.24.18),
    b. Class (e.g., ENGR 102),
    c. Instructor (last initial first initial – e.g., MT)
    d. No. students (please look this up in Howdy)
        i. howdy.tamu.edu
        ii. My Record
        iii. Search Class Schedule
        iv. Fall 2018 – College Station
        v. Find the courses Subject
        vi. Click on the Course's "View Section"
        vii. Find your section and record the number of students registered (i.e., Act column) – make sure to check to see if there is an Honors section in addition to the regular section – combine both "Act" columns if there is.
    - Observer name (first initial.last name – e.g., S.Shields)

4. Put your cursor in cell A3. Cell A3 will allow you to input the Classroom Arrangement.

   a. ZACH ### - large learning studio – 6 to 7 large monitors mounted, whiteboards along the walls, 25 tables of 4 - (no or yes) assigned seating

   b. ZACH ### - small learning studio - 3 large monitors mounted, whiteboards along the walls, 12 tables of 4 - _(no or yes)_ assigned seating

   c. Non-ZACH room example – YMCA ### – there are 6 rows of 6 and 2 row of 7 with 12 extra desks along the walls – the lectern is at the front right with a projector screen and whiteboards across the front - _(no or yes)_ assigned seating

5. For each 2 minute interval, mark columns (with a lower case x) to show what's happening in each category. On each spreadsheet row, mark **all** that you see the 1. Students Doing and the 2. Instructor Doing. Check multiple columns where appropriate.
   a. If you select **Other, Waiting, and/or Admin**., please include comments in the far right Comments column as to what was happening (e.g., instructor was late to class, instructor was having IT difficulties, etc).

6. After 2 minutes, move to the next spreadsheet row and begin marking for that 2 minute interval.

7. Mark for the first 50 minutes of a class, even in a T/R class or class longer than 50 min. Quit marking if the instructor ends class early, make a note of this in the Comments column.

8. For the 3. Student Engagement column, I go by the 3. Student Engagement box at the bottom of the COPUS codes page. H is used if 80+% of students are clearly engaged. To determine 80%, I take the total number of students and multiply that number by .2. That will give you 20%. I then count the number of students not engaged and see if it is more or less than 20%. More than your 20% number not engaged, I choose M or L. Less that your 20% number, I choose the H.

   For example, if there are 80 students in the class, 80 times .2 is 16. So, if less than 16 students appear not engaged, then I check the H column. If more than 16 students appear not engaged, then I check the M or L column…depending.

9. I have made you a copy of an observation spreadsheet that Emily and I did together. I would recommend you refer to this often as you observe, as well as your COPUS code sheet, to be consistent with what you are seeing.

10. SAVE FREQUENTLY!!

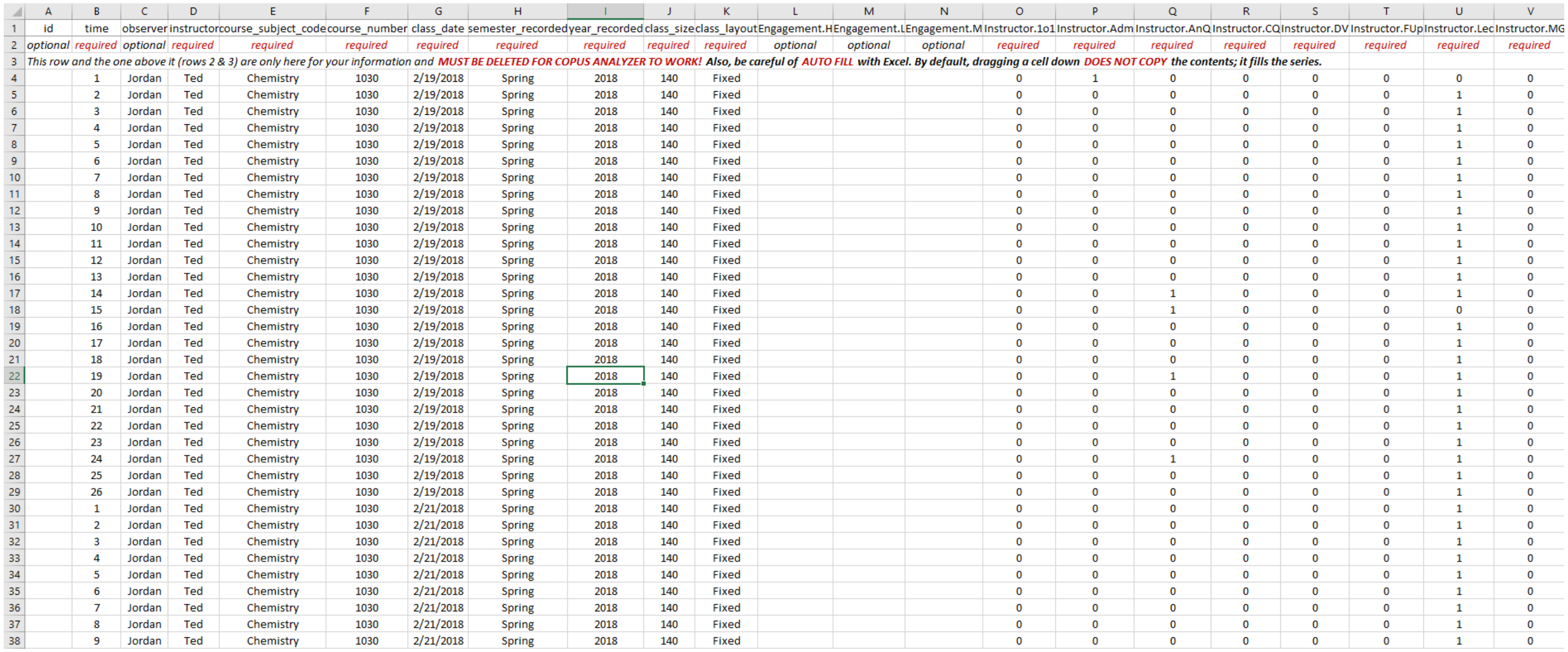
11. Please email me (s.shields@tamu.edu) at the end of each day that you do observations. Include which instructors you observed that day. I will send "thank you" emails the following day, CCing you on those thank you emails.

12. Please know just how appreciative I am of your assistance with this!!!

APPENDIX G

COPUS ANALYZER – MINUTE-BY-MINUTE TEMPLATE EXAMPLE

“COPUS Analyzer – Minute-by-Minute Template” by Marilyn Stains and Jordan Harshman is licensed under Attribution-Noncommercial 3.0 Unported License https://creativecommons.org/licenses/by-nc/3.0/. Available at http://www.copusprofiles.org/. The data below is sample data provided on the COPUS Analyzer website. It is not real data.

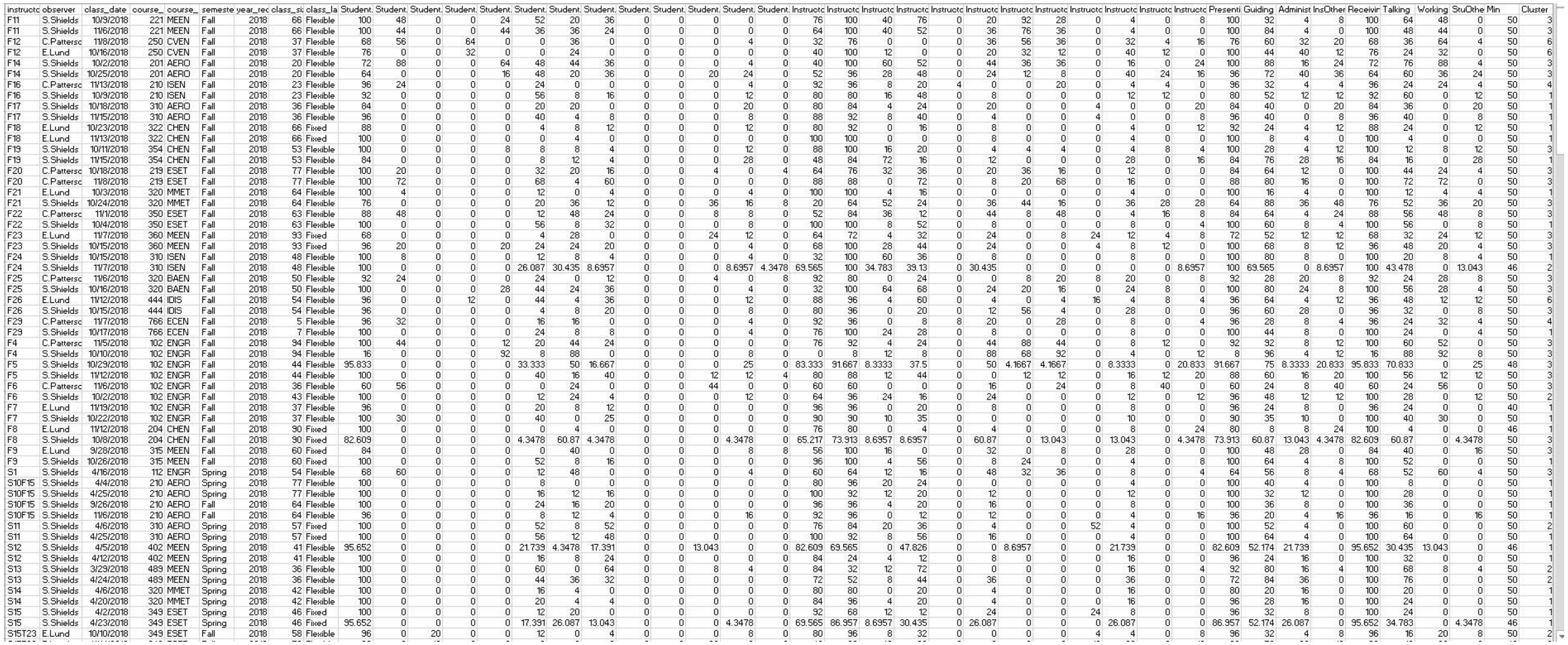


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	id	time	observer	instructor	course_subject_code	course_number	class_date	semester_recorded	year_recorded	class_size	class_layout	Engagement.H	Engagement.L	Engagement.M	Instructor.1o1	Instructor.Adm	Instructor.AnQ	Instructor.CQ	Instructor.DV	Instructor.FUp	Instructor.Lec	Instructor.MG
2	*optional*	*required*	*optional*	*required*	*required*	*required*	*required*	*required*	*required*	*required*	*required*	*optional*	*optional*	*optional*	*required*	*required*	*required*	*required*	*required*	*required*	*required*	*required*
3	*This row and the one above it (rows 2 & 3) are only here for your information and* ***MUST BE DELETED FOR COPUS ANALYZER TO WORK! Also, be careful of AUTO FILL with Excel. By default, dragging a cell down DOES NOT COPY the contents; it fills the series.***																					
4		1	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	1	0	0	0	0	0	0
5		2	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
6		3	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
7		4	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
8		5	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
9		6	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
10		7	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
11		8	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
12		9	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
13		10	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
14		11	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
15		12	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
16		13	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
17		14	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	1	0	0	0	1	0
18		15	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	1	0	0	0	0	0
19		16	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
20		17	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
21		18	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
22		19	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	1	0	0	0	1	0
23		20	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
24		21	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
25		22	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
26		23	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
27		24	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	1	0	0	0	1	0
28		25	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
29		26	Jordan	Ted	Chemistry	1030	2/19/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
30		1	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
31		2	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
32		3	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
33		4	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
34		5	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
35		6	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
36		7	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
37		8	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0
38		9	Jordan	Ted	Chemistry	1030	2/21/2018	Spring	2018	140	Fixed				0	0	0	0	0	0	1	0

APPENDIX H

COPUS ANALYZER – COPUS SUMMARY

“COPUS Analyzer – COPUS Summary” by Marilyn Stains and Jordan Harshman is licensed under Attribution-Noncommercial 3.0 Unported License https://creativecommons.org/licenses/by-nc/3.0/. Available at http://www.copusprofiles.org/.



instructc	observer	class_date	course_	course_	semeste	year_rec	class_si	class_la	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Student.	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Instructc	Presenti	Guiding	Administ	InsOther	Receivir	Talking	Working	StuOthe	Min	Cluster
F11	S.Shields	10/9/2018	221	MEEN	Fall	2018	66	Flexible	100	48	0	0	24	52	20	36	0	0	0	0	0	76	100	40	76	0	20	92	28	0	4	0	8	100	92	4	8	100	64	48	0	50	3
F11	S.Shields	11/6/2018	221	MEEN	Fall	2018	66	Flexible	100	44	0	0	44	36	36	24	0	0	0	0	0	64	100	40	52	0	36	76	36	0	4	0	0	100	84	4	0	100	48	44	0	50	3
F12	C.Pattersc	11/8/2018	250	CVEN	Fall	2018	37	Flexible	68	56	0	64	0	0	36	0	0	0	0	4	0	32	76	0	0	0	36	56	36	0	32	4	16	76	60	32	20	68	36	64	4	50	6
F12	E.Lund	10/16/2018	250	CVEN	Fall	2018	37	Flexible	76	0	0	32	0	0	24	0	0	0	0	0	0	40	100	12	0	0	20	32	12	0	40	12	0	100	44	40	12	76	24	32	0	50	6
F14	S.Shields	10/2/2018	201	AERO	Fall	2018	20	Flexible	72	88	0	0	64	48	44	36	0	0	0	4	0	40	100	60	52	0	44	36	36	0	16	0	24	100	88	16	24	72	76	88	4	50	3
F14	S.Shields	10/25/2018	201	AERO	Fall	2018	20	Flexible	64	0	0	0	16	48	20	36	0	0	20	24	0	52	96	28	48	0	24	12	8	0	40	24	16	96	72	40	36	64	60	36	24	50	3
F16	C.Pattersc	11/13/2018	210	ISEN	Fall	2018	23	Flexible	96	24	0	0	0	24	0	0	0	0	0	4	0	92	96	8	20	4	0	0	20	0	4	4	0	96	32	4	4	96	24	24	4	50	4
F16	S.Shields	10/9/2018	210	ISEN	Fall	2018	23	Flexible	92	0	0	0	0	56	8	16	0	0	0	12	0	80	80	16	48	0	8	0	0	0	12	12	0	80	52	12	12	92	60	0	12	50	1
F17	S.Shields	10/18/2018	310	AERO	Fall	2018	36	Flexible	84	0	0	0	0	20	20	0	0	0	0	20	0	80	84	4	24	0	20	0	0	4	0	0	20	84	40	0	20	84	36	0	20	50	1
F17	S.Shields	11/15/2018	310	AERO	Fall	2018	36	Flexible	96	0	0	0	0	40	4	8	0	0	0	8	0	88	92	8	40	0	4	0	0	4	0	0	8	96	40	0	8	96	40	0	8	50	1
F18	E.Lund	10/23/2018	322	CHEN	Fall	2018	66	Fixed	88	0	0	0	0	4	8	12	0	0	0	12	0	80	92	0	16	0	8	0	0	0	4	0	12	92	24	4	12	88	24	0	12	50	1
F18	E.Lund	11/13/2018	322	CHEN	Fall	2018	66	Fixed	100	0	0	0	0	0	4	0	0	0	0	0	0	100	100	0	0	0	8	0	0	0	4	0	0	100	8	4	0	100	4	0	0	50	1
F19	S.Shields	10/11/2018	354	CHEN	Fall	2018	53	Flexible	100	0	0	0	8	8	8	4	0	0	0	12	0	88	100	16	20	0	4	4	4	0	4	8	4	100	28	4	12	100	12	8	12	50	3
F19	S.Shields	11/15/2018	354	CHEN	Fall	2018	53	Flexible	84	0	0	0	0	8	12	4	0	0	0	28	0	48	84	72	16	0	12	0	0	0	28	0	16	84	76	28	16	84	16	0	28	50	1
F20	C.Pattersc	10/18/2018	219	ESET	Fall	2018	77	Flexible	100	20	0	0	0	32	20	16	0	0	4	0	4	64	76	32	36	0	20	36	16	0	12	0	0	84	64	12	0	100	44	24	4	50	3
F20	C.Pattersc	11/8/2018	219	ESET	Fall	2018	77	Flexible	100	72	0	0	0	68	4	60	0	0	0	0	0	88	88	0	72	0	8	20	68	0	16	0	0	88	80	16	0	100	72	72	0	50	3
F21	E.Lund	10/3/2018	320	MMET	Fall	2018	64	Flexible	100	4	0	0	0	12	0	4	0	0	0	4	0	100	100	4	16	0	0	0	0	0	4	0	0	100	16	4	0	100	12	4	4	50	1
F21	S.Shields	10/24/2018	320	MMET	Fall	2018	64	Flexible	76	0	0	0	0	20	36	12	0	0	36	16	8	20	64	52	24	0	36	44	16	0	36	28	28	64	88	36	48	76	52	36	20	50	3
F22	C.Pattersc	11/1/2018	350	ESET	Fall	2018	63	Flexible	88	48	0	0	0	12	48	24	0	0	8	8	0	52	84	36	12	0	44	8	48	0	4	16	8	84	64	4	24	88	56	48	8	50	3
F22	S.Shields	10/4/2018	350	ESET	Fall	2018	63	Flexible	100	0	0	0	0	56	8	32	0	0	0	8	0	100	100	8	52	0	8	0	0	0	8	0	4	100	60	8	4	100	56	0	8	50	1
F23	E.Lund	11/7/2018	360	MEEN	Fall	2018	93	Fixed	68	0	0	0	0	4	28	0	0	0	24	12	0	64	72	4	32	0	24	0	8	24	12	4	8	72	52	12	12	68	32	24	12	50	3
F23	S.Shields	10/15/2018	360	MEEN	Fall	2018	93	Fixed	96	20	0	0	20	24	24	20	0	0	0	4	0	68	100	28	44	0	24	0	0	4	8	12	0	100	68	8	12	96	48	20	4	50	3
F24	S.Shields	10/15/2018	310	ISEN	Fall	2018	48	Flexible	100	8	0	0	0	12	8	4	0	0	0	4	0	32	100	60	36	0	8	0	0	0	8	0	0	100	80	8	0	100	20	8	4	50	1
F24	S.Shields	11/7/2018	310	ISEN	Fall	2018	48	Flexible	100	0	0	0	0	26.087	30.435	8.6957	0	0	0	8.6957	4.3478	69.565	100	34.783	39.13	0	30.435	0	0	0	0	0	8.6957	100	69.565	0	8.6957	100	43.478	0	13.043	46	2
F25	C.Pattersc	11/6/2018	320	BAEN	Fall	2018	50	Flexible	92	24	0	0	0	24	0	12	0	0	4	0	8	92	80	0	24	0	0	8	20	8	20	0	8	92	28	20	8	92	24	28	8	50	3
F25	S.Shields	10/16/2018	320	BAEN	Fall	2018	50	Flexible	100	0	0	0	28	44	24	36	0	0	0	4	0	32	100	64	68	0	24	20	16	0	24	8	0	100	80	24	8	100	56	28	4	50	3
F26	E.Lund	11/12/2018	444	IDIS	Fall	2018	54	Flexible	96	0	0	12	0	44	4	36	0	0	0	12	0	88	96	4	60	0	4	0	4	16	4	8	4	96	64	4	12	96	48	12	12	50	6
F26	S.Shields	10/15/2018	444	IDIS	Fall	2018	54	Flexible	96	0	0	0	0	4	8	20	0	0	0	8	0	80	96	0	20	0	12	56	4	0	28	0	0	96	60	28	0	96	32	0	8	50	3
F29	C.Pattersc	11/7/2018	766	ECEN	Fall	2018	5	Flexible	96	32	0	0	0	16	16	0	0	0	0	4	0	92	96	0	8	8	20	0	28	0	8	0	4	96	28	8	4	96	24	32	4	50	4
F29	S.Shields	10/17/2018	766	ECEN	Fall	2018	7	Flexible	100	0	0	0	0	24	8	8	0	0	0	4	0	76	100	24	28	0	8	0	0	0	8	0	0	100	44	8	0	100	24	0	4	50	1
F4	C.Pattersc	11/5/2018	102	ENGR	Fall	2018	94	Flexible	100	44	0	0	12	20	44	24	0	0	0	0	0	76	92	4	24	0	44	88	44	0	8	12	0	92	92	8	12	100	60	52	0	50	3
F4	S.Shields	10/10/2018	102	ENGR	Fall	2018	94	Flexible	16	0	0	0	92	8	88	0	0	0	0	8	0	0	8	12	8	0	88	68	92	0	4	0	12	8	96	4	12	16	88	92	8	50	3
F5	S.Shields	10/29/2018	102	ENGR	Fall	2018	44	Flexible	95.833	0	0	0	0	33.333	50	16.667	0	0	0	25	0	83.333	91.667	8.3333	37.5	0	50	4.1667	4.1667	0	8.3333	0	20.833	91.667	75	8.3333	20.833	95.833	70.833	0	25	48	3
F5	S.Shields	11/12/2018	102	ENGR	Fall	2018	44	Flexible	100	0	0	0	0	40	16	40	0	0	12	12	4	80	88	12	44	0	0	12	12	0	16	12	20	88	60	16	20	100	56	12	12	50	3
F6	C.Pattersc	11/6/2018	102	ENGR	Fall	2018	36	Flexible	60	56	0	0	0	0	24	0	0	0	44	0	0	60	60	0	0	0	16	0	24	0	8	40	0	60	24	8	40	60	24	56	0	50	3
F6	S.Shields	10/2/2018	102	ENGR	Fall	2018	43	Flexible	100	0	0	0	0	12	24	4	0	0	0	12	0	64	96	24	16	0	24	0	0	0	12	0	12	96	48	12	12	100	28	0	12	50	2
F7	E.Lund	11/19/2018	102	ENGR	Fall	2018	37	Flexible	96	0	0	0	0	20	8	12	0	0	0	0	0	96	96	0	20	0	8	0	0	0	8	0	0	96	24	8	0	96	24	0	0	40	1
F7	S.Shields	10/22/2018	102	ENGR	Fall	2018	37	Flexible	100	30	0	0	0	40	0	25	0	0	0	0	0	90	90	10	35	0	0	0	0	0	10	0	0	90	35	10	0	100	40	30	0	50	1
F8	E.Lund	11/12/2018	204	CHEN	Fall	2018	90	Fixed	100	0	0	0	0	0	4	0	0	0	0	0	0	76	80	0	4	0	4	0	0	0	8	0	24	80	8	8	24	100	4	0	0	46	1
F8	S.Shields	10/8/2018	204	CHEN	Fall	2018	90	Fixed	82.609	0	0	0	0	4.3478	60.87	4.3478	0	0	0	4.3478	0	65.217	73.913	8.6957	8.6957	0	60.87	0	13.043	0	13.043	0	4.3478	73.913	60.87	13.043	4.3478	82.609	60.87	0	4.3478	50	3
F9	E.Lund	9/28/2018	315	MEEN	Fall	2018	60	Fixed	84	0	0	0	0	0	40	0	0	0	0	8	8	56	100	16	0	0	32	0	8	0	28	0	0	100	48	28	0	84	40	0	16	50	3
F9	S.Shields	10/26/2018	315	MEEN	Fall	2018	60	Fixed	100	0	0	0	0	52	8	16	0	0	0	0	0	96	100	4	56	0	8	24	0	0	4	0	8	100	64	4	8	100	52	0	0	50	1
S1	S.Shields	4/16/2018	112	ENGR	Spring	2018	54	Flexible	68	60	0	0	0	12	48	0	0	0	0	4	0	60	64	12	16	0	48	32	36	0	8	0	4	64	56	8	4	68	52	60	4	50	3
S10F15	S.Shields	4/4/2018	210	AERO	Spring	2018	77	Flexible	100	0	0	0	0	8	0	0	0	0	0	0	0	80	96	20	24	0	0	0	0	0	4	0	0	100	40	4	0	100	8	0	0	50	1
S10F15	S.Shields	4/25/2018	210	AERO	Spring	2018	77	Flexible	100	0	0	0	0	16	12	16	0	0	0	0	0	100	92	12	20	0	12	0	0	0	12	0	0	100	32	12	0	100	28	0	0	50	1
S10F15	S.Shields	9/26/2018	210	AERO	Fall	2018	64	Flexible	100	0	0	0	0	24	16	20	0	0	0	0	0	96	96	4	20	0	16	0	0	0	8	0	0	100	36	8	0	100	36	0	0	50	1
S10F15	S.Shields	11/6/2018	210	AERO	Fall	2018	64	Flexible	96	0	0	0	0	8	12	4	0	0	0	16	0	92	96	0	12	0	12	0	0	0	4	0	16	96	20	4	16	96	16	0	16	50	1
S11	S.Shields	4/6/2018	310	AERO	Spring	2018	57	Fixed	100	0	0	0	0	52	8	52	0	0	0	0	0	76	84	20	36	0	4	0	0	52	4	0	0	100	52	4	0	100	60	0	0	50	2
S11	S.Shields	4/25/2018	310	AERO	Spring	2018	57	Fixed	100	0	0	0	0	56	12	48	0	0	0	0	0	100	92	8	56	0	16	0	0	0	4	0	0	100	64	4	0	100	64	0	0	50	1
S12	S.Shields	4/5/2018	402	MEEN	Spring	2018	41	Flexible	95.652	0	0	0	0	21.739	4.3478	17.391	0	0	13.043	0	0	82.609	69.565	0	47.826	0	0	8.6957	0	0	21.739	0	0	82.609	52.174	21.739	0	95.652	30.435	13.043	0	46	1
S12	S.Shields	4/12/2018	402	MEEN	Spring	2018	41	Flexible	100	0	0	0	0	16	8	24	0	0	0	0	0	84	24	4	12	0	8	0	0	0	16	0	0	96	24	16	0	100	32	0	0	50	1
S13	S.Shields	3/29/2018	489	MEEN	Spring	2018	36	Flexible	100	0	0	0	0	60	0	64	0	0	8	4	0	84	32	12	72	0	0	0	0	0	16	0	4	92	80	16	4	100	68	8	4	50	2
S13	S.Shields	4/24/2018	489	MEEN	Spring	2018	36	Flexible	100	0	0	0	0	44	36	32	0	0	0	0	0	72	52	8	44	0	36	0	0	0	36	0	0	72	84	36	0	100	76	0	0	50	2
S14	S.Shields	4/6/2018	320	MMET	Spring	2018	42	Flexible	100	0	0	0	0	16	4	0	0	0	0	0	0	80	80	0	20	0	4	0	0	0	16	0	0	80	20	16	0	100	20	0	0	50	1
S14	S.Shields	4/20/2018	320	MMET	Spring	2018	42	Flexible	100	0	0	0	0	20	4	4	0	0	0	0	0	84	96	4	20	0	4	0	0	0	16	0	0	96	28	16	0	100	24	0	0	50	1
S15	S.Shields	4/2/2018	349	ESET	Spring	2018	46	Fixed	100	0	0	0	0	12	20	0	0	0	0	0	0	92	68	12	12	0	24	0	0	24	8	0	0	96	32	8	0	100	24	0	0	50	1
S15	S.Shields	4/23/2018	349	ESET	Spring	2018	46	Fixed	95.652	0	0	0	0	17.391	26.087	13.043	0	0	0	4.3478	0	69.565	86.957	8.6957	30.435	0	26.087	0	0	0	26.087	0	0	86.957	52.174	26.087	0	95.652	34.783	0	4.3478	46	1
S15T23	E.Lund	10/10/2018	349	ESET	Fall	2018	58	Flexible	96	0	20	0	0	12	0	4	0	0	0	8	0	80	96	8	32	0	0	0	0	4	4	0	8	96	32	4	8	96	16	20	8	50	2

APPENDIX I

ACTIVE LEARNING IN ENGINEERING PROGRAM INFORMATION SHEET

TEXAS A&M UNIVERSITY HUMAN SUBJECTS PROTECTION PROGRAM

Information Sheet

Project Title: Active Learning in Engineering Program

You are invited to take part in an exempt research project conducted by the Active Learning in Engineering Program (ALEP) Research Team from the College of Engineering, the Center for Teaching Excellence (CTE), Instructional Technology Services (ITS), and the TEES Institute for Engineering Education and Innovation (IEEI) at Texas A&M University (TAMU). The information in this form is provided to help you decide whether or not to take part. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefits that you normally would have.

Purpose of the Study: This project is to research preparing and supporting faculty as they transition pedagogical paradigms into those that engage and cultivate students in active learning environments, such as those in the new Zachry Engineering Education Complex (ZACH).

Eligibility: Any TAMU faculty member who teaches at least one course a semester.

Procedures:
If you choose to participate in this study, you will have an opportunity to participate in four research activities:

1. An online survey - includes Likert-type items and open-ended questions about faculty's knowledge, perceptions and practice in active learning, as well as demographic questions. The online survey will be given three times during the project as a pre-, post-, and post-post measure to understand faculty's development in knowledge, perceptions and practice of active learning. The survey will take at most 10 minutes.

2. The Teaching Practices Inventory - an online survey used to gather information about the types of instructional methods (i.e., teaching practices) faculty currently use in the classroom. The online survey will be given three times during the project as a pre-, post-, and post-post measure to understand faculty's adoption of active learning strategies. The survey will take at most 10 minutes.

3. Classroom Observations - in the semester during and the semester after project participation, trained observers will complete two classroom observations using the Classroom Observation Protocol for Undergraduate STEM (COPUS) on the activities in the classroom. Because this is time that the participant would already be teaching,

the only additional time needed for this research activity is the time required to coordinate and schedule observation dates.

4. Workshop documents - includes workshop evaluations and/or critical incident questionnaires, participant workshop notes pages, and participant active learning adoption plans. These documents provide the research team with firsthand accounts of the Program's impact, as well as feedback for Program changes.

Risks: The risk involved in this study will be no greater than you would come across in everyday life. The probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

Benefits: There will be no direct benefits to your participation in this study. However, the results of the study are expected to assist in the development of future faculty active learning trainings.

Compensation: There will be no monetary compensation for participation in this study.

Confidentiality: The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Only the Principal Investigator and research study personnel will have access to your information. Information about you will be stored securely in locked file cabinet or computer files protected with a password. This consent form will be filed securely in an official area.

Voluntary Nature of Participation: This research is voluntary and you have the choice whether or not to be in this research study. You may decide to not begin or to stop participating at any time. If you choose not to be in this study or stop being in the study, there will be no effect on your status or relationship with Texas A&M University, etc. Representatives of regulatory agencies, such as the Office of Human Research Protections (OHRP), and entities, such as the Texas A&M University Human Subjects Protection Program, may access your records to make sure the study is being run correctly and that information is collected properly. Information about you and related to this study will be kept confidential to the extent permitted or required by law.

You may contact the Principal Investigator, Dr. Michael de Miranda, to tell him about a concern or complaint about this research at 979-845-8384 or demiranda@tamu.edu. For an alternate contact, you may also contact the Additional Principal Investigator, Dr. Debra Fowler at dfowler@tamu.edu or either Co- Principal Investigators, Dr. Karan Watson at watson@tamu.edu or Sunay Palsole at sunay.palsole@tamu.edu.

For questions about your rights as a research participant, to provide input regarding research, or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Subjects Protection Program office by phone at 1-979-458-4067, toll free at 1-855-795-8636, or by email at irb@tamu.edu.