FACULTY INTENTION AND FACULTY IMPLEMENTATION-DO THEY ALIGN?

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Laura Ann Paulson

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Biological Sciences

March 2021

Fargo, North Dakota

North Dakota State University
Graduate School

Title

FACULTY INTENTION AND FACULTY IMPLEMENTATION-
DO THEY ALIGN?

By

Laura Ann Paulson

The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

SUPERVISORY COMMITTEE:

Dr. Lisa Montplaisir
Chair

Dr. Julia Bowsher

Dr. Jared Ladbury

Approved:

April 8, 2021 — Date

Dr. Kendra Greenlee — Department Chair

ABSTRACT

There have been a multitude of calls to reform teaching in undergraduate education. The implementation of active learning in the classroom increases student learning, relative to traditional lecturing. I worked with university faculty to determine the relationship between their interest in (intent) and application of active learning (behavior). I measured the intent of faculty to implement active learning and conducted classroom observations. Based on these classroom, observations, I found there is not always an alignment between an individual's intent and behavior. Therefore, interviews were conducted to determine what factors could be contributing to the misalignment. Several factors were found: preparation time of new activities, classroom setup/layout, and the student population. Understanding what factors impact the change from traditional teaching to active learning teaching creates an opportunity to provide faculty with remedies such factors.

ACKNOWLEDGMENTS

First, I would like to thank my advisor, Lisa Montplaisir, for guidance throughout my graduate school career. She's shared an abundance of knowledge and insight over the past three years and that has been critical to my learning and understanding of education research. Completing my degree would have been difficult without her help and persistence to see me graduate.

I am also very grateful for the advice and discussion from my other two committee members, Julia Bowsher and Jared Ladbury. Jared was monumental in the analysis and understanding of the COPUS statistics performed in this study. I owe a big thank you to Paul Kelter for finding the financial means for me to be able to stay in school and complete my education. My numerous encounters with him have shown me a passion for learning and teaching that is hard to surpass.

I am fortunate to have supportive lab members, Rebecca Reichenbach, Cedar Walters, Melody McConnell, and Maria Guixe Viedma, whom have kept me motivated and moving forward with my research. They have also provided me with an environment to freely discuss ideas and to receive a valuable feedback on both schoolwork and my research.

Lastly, I 'd like to thank my family, especially my wonderful parents, Steve and Judy, my sister Jen, and my husband Alex for unwavering support and patience with me completing this degree. Without their guidance, support, and wisdom I would not have been able to endure graduate school and finish my degree.

This project was supported by the National Science Foundation under NSF DUE-1525056.

DEDICATION

This disquisition is dedicated to my parents, my sister, and my husband. This would not have been possible without their years of unwavering support, help, and love.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Undergraduate science, technology, engineering and mathematic (STEM) courses have been the center of interest for many education researchers of late. STEM courses service a diverse, robust student body as well as a variety of majors and disciplines. This diversity in both content (course description, course level, course enrollment) and students (ethnicity, age, background education, career goals) has led to national attention and focus on reforming the way STEM courses are taught. There is a push to progress teaching strategies from traditional lecturing method to a more active, inquiry-based, student engaging approach.

Even though the nation's attention is drawn to STEM education reform, the field of STEM education research itself is relatively new and undiscovered. There has been extensive research on introductory biology courses, but beyond that little is known about other course levels and class sizes across various disciplines. Being able to understand how active learning can be used in any type of classroom and course is important if the goal is to implement change throughout a university.

The term 'active teaching' is used to describe a teaching style where students are participants in their learning (Bonwell & Eison, 1991). Active learning is a relatively broad term that encompasses an extensive spectrum of strategies that have evidence of effectiveness within the classroom. These strategies include think-pair-share, clicker questions, group discussions, or group projects, just to name a few. Even though these strategies have shown to be successful ways to engage students in their learning, they are still not widely used across the STEM courses.

Gateways ND was initiated at North Dakota State University with a National Science Foundation (NSF) award with the goal of increasing the use of active learning strategies and practices that are being incorporated in the STEM courses along with the desire to create an active learning community on campus for faculty members.

Gateways ND

Gateways ND is a five-year NSF funded program designed to increase faculty knowledge of pedagogy, development of said pedagogy, and implementation of such within their classroom. Faculty participants attitudes and beliefs toward active learning were tracked and monitored while they were part of this program. Additionally, classroom observations were performed to try and find a correlation between their pedagogical beliefs and pedagogical practices.

The program aimed to inform faculty of active pedagogical practices and create a community in which faculty could engage with each other and discuss different teaching approaches and strategies. For faculty to have successful change of what teaching strategies they were using, the barriers they are encountering had to be taken into consideration and addressed. One of the more pronounced perceived barriers is that students will not participate or engage in active learning. A few other barriers include the influence outside entities has on traditional teaching, faculty self-perceptions, the anxiety that change can cause, and the lack of incentive for faculty to diverge from traditional lecturing (Bonwell & Eison, 1991).

For the purpose of this study, having diversity was important. The study encompasses a broad spectrum of faculty, student enrollment numbers, course levels, and departments in order to gain a better understanding of how active learning can be used across the university.

This study was formulated to address the following research questions:

1. To what extent do faculty attitudes, norms (beliefs about others' beliefs and actions), and personal control beliefs regarding implementing active teaching and

learning strategies influence the implementation of active teaching and learning strategies?

2. If faculty intend to implement active learning and teaching strategies in their classroom, are they practicing said strategies?

This research was also informed by the hypotheses:

1. Faculty are encountering barriers that inhibit implementing active learning and teaching strategies
2. Faculty need the support of peers to encourage pedagogical change

This project sought to determine whether there is alignment between faculty intention and faculty practices. Further, identification of what barriers exist, or are thought to exist, can inform future professional development workshops. Together this information can lead to better student and faculty experiences in the classroom.

LITERATURE REVIEW

Current state of STEM education research

What is STEM education? STEM education is defined as "a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one dynamic, fluid study" (Merrill, 2009). A study that intended to determine the current perceptions of STEM education found that only half of the people (STEM faculty, non-STEM faculty, and administrators) asked "what is STEM education?" were able to correctly answer the question. Even though only half of the interviewed population knew what STEM education was, 75% stated that STEM education was important (Brown, Brown, Reardon, & Merrill, 2011). This suggested that a majority believe in the value of STEM education, but have a blurred vision of what it means (Brown, Brown, Reardon, & Merrill, 2011). If people are not aware of what STEM education means, effectively teaching it may deem difficult. Knowing the current understanding held by most individuals regarding STEM education is important when evaluating where the research should go and what should be looked at next.

A study that attempted to determine the state of STEM education research looked at and analyzed 60 self-identified STEM education research articles (Brown, 2012). After gathering a database of articles, researchers attempted to answer four main questions. The first question asked addressed if there is a research base available to STEM education researchers; is there a platform for this research? The next three questions aimed to address the scope of STEM education, where are the studies being conducted, and to whom/to what education level the studies were being conducted? The articles were initially placed into one of seven categories for frequency of article method; activity, descriptive, editorial, literature, mixed method, qualitative, and quantitative. The methods of the 60 articles were distributed evenly across the seven categories except for the editorial and literature categories which, when combined, had a total of five articles. The articles were then sorted by institution and who the study focused on. They found that STEM education research is being conducted at a range of institutions which suggests that there is interest and that opportunities are readily available. Only 14 of the 60 articles focused on undergraduates or faculty as their population, whereas a third of the articles concentrated on K-12 students and or teachers (Brown, 2012). The remaining articles participants were graduate students, did not have participants, or used faculty as the participants (Brown, 2012).

In 2008, the National Research Council hosted two workshops with one goal in mind; "to examine the evidence of impact for a selected number of promising practices". After the workshop, Dr. James Fairweather, discussed new ideas in a status report for The National Academies National Research Council Board of Science Education. He suggested there was substantial evidence which showed increased student learning via inquiry-based learning approaches. He debated that student learning would progress quicker if faculty that used traditional teaching pedagogies could be convinced to change their practices (from traditional to active strategies), if only just slightly. Fairweather stated institutions that value research over teaching discourage faculty to transform their teaching and use effective practices (Fairweather, 2010). Conclusions drawn from the workshops led to asking what teaching approaches are discipline specific and what strategies can be interdisciplinary (Labov, Singer, George, Schweingruber, & Hilton, 2009).

Call for reform in undergraduate STEM courses

In the past decades there have been a multitude of calls to reform undergraduate STEM courses (Bybee, 2010; Fairweather, 2010; Goldberg & Harvey, 1983). "Now is the time to move beyond the slogan and make STEM literacy for all students an educational priority" (Bybee, 2010). The calls have come from a variety of places with diverse reasons. The first major call came from a national report titled "A Nation at Risk" (Goldberg & Harvey, 1983). A decline in the number of students pursuing degrees in STEM programs was the main contributing factor which led to this call. Additionally, the number of STEM graduates continuing on to graduate school is decreasing (Fairweather, 2010).

Since these calls for reform, it has been agreed that science education is best done via scientific teaching (ST). ST has three central facets: active learning, assessment, and inclusivity (Couch, et al., 2015). Reaching students can be done by engaging them in their learning process and having them partake in the responsibility of their learning. Even with agreement throughout faculty, change has not progressively happened nor is it propelled by research universities (Handelsman et al., 2010).

Importance of active learning in undergraduate STEM courses

Faculty implementation of active learning is important in student learning because studies have provided evidence that implementing active learning has a positive impact on the quality student learning (Freeman et al., 2014). In a meta-analysis of 225 studies, there was an average increase of 6% on exam scores in active learning sections in comparison to non-active learning sections (Freeman et al., 2014). Additionally, students in traditional lecture-based classrooms were 1.5 times more likely to fail a course than students in a course utilizing active learning practices (Freeman et al., 2014). Active learning contributes to students' development of independent learning skills and their ability to apply the content they are learning. Two independent skills that students develop are critical thinking and problem solving (Sivan et al., 2000). Along with increasing student learning, active learning is known to positively affect student performance. Active learning increases exam performance whereas lecturing shows an increase in the failure rate of students (Freeman et al., 2014). Increasing active learning could potentially decrease the achievement gap that is frequently seen in introductory classes (Haak, HilleRisLambers, Pitre, & Freeman, 2011).

Creating an active learning environment

A continuum of teaching styles exist in the undergraduate STEM courses with the two endcaps being interactive teaching and traditional lecture-based teaching (Smith, Vinson, Smith, Lewin, & Stetzer, 2014). In an active learning environment, it is imperative that the instructor shifts the responsibility of learning from themselves to their students. One method to facilitate this shift is known as cooperative learning. The greater the shift of responsibility, the greater the ownership and pride the students will take in their learning and in the course itself (Ebert-May, Brewer, & Allred, 2016).

Another factor in creating an active learning environment is ensuring there is alignment between course goals, course outcomes, and the assessments being used to gauge them. The application of backward design is a large component of the pedagogical approach used in active classrooms. Backward design urges instructors to first determine what outcomes they want the students to obtain in the course. Once the course outcomes are identified, the instructor can then create assessments and performance tasks that will guide students towards the achievement of those outcomes (McTighe, Seif, & Wiggins, 2004).

There are multiple active learning strategies that could be utilized in undergraduate courses. These include but not limited to; think-pair share, clicker questions, and small group discussions, all of which were observed during our observations on campus.

Think-Pair-Share is a strategy that can be utilized in various learning scenarios, specifically when working on higher order thinking prompts. This strategy works in three phases, the first being, think. The instructor starts by providing an instruction, question, or observation that is designed to provoke student thinking. The second stage is pair, in which students pair up and share the answers they had derived during the 'think' stage. If the students had come up with different answers, they can explain their answers and decide which of their responses they deem to be correct. The final stage is share. The instructor asks various groups of students to share their answers with the rest of the class. If there are incorrect answers or misconceptions that arise, the instructor is given an opportunity to address those during this time (Robertson, 2006).

Another active learning strategy frequently used is a classroom response system (CRS). Clicker questions are an example of CRS. During clicker questions, instructors pose a question and provide a multiple-choice answer section. Students are given time to think about their answer, and then they are asked to submit their answer via the CRS. Once the students have answered, the instructor can view the results (and show them to the classroom if they choose to do so). Using this type of assessment can provide the instructor with real time feedback and gauge the level of student understanding of concepts being taught in class.

Small group discussions are also utilized in undergraduate courses. Providing students with a platform to discuss any questions/comments/concerns with their peers can be beneficial in a multitude of ways: (1) increase in conductivity to higher-order learning and critical thinking,

(2) increase in equal participation among members of a small group versus a large group, and (3) an increase in students overall satisfaction with discussions (Philip et al., 2011).

Perceived barriers to creating an active learning environment

Prior to creating an active learning environment, there are barriers that often lead faculty to be apprehensive about implementing active teaching practices, regardless of whether those perceived barriers are accurate. Perceptions about barriers can be grouped into three categories: student characteristics, pedagogical issues, and factors directly impacting faculty (Michael, 2007). A group of faculty members volunteered to participate in a workshop that focused on determining their perceived barriers to utilizing active learning strategies. The workshop facilitators divided the study participants into four separate groups in order to make the group size more manageable. There were two barriers that all four participant groups synthesized. Those two barriers are (1) that active learning requires too much preparation time and (2) the classrooms they teach in is not conducive for active learning implementation. Two solutions were then proposed change those perceived barriers. The first solution was to increase faculty development. However, it is thought such development could be ineffective due to time constraints and limited resources. The second proposed solution was to treat teaching like a scholarly solitary activity, suggesting, instead of teaching being viewed as a solitary activity, it needs to be shared and discussed between peers, departments and other institutional colleagues (Michael, 2007).

Additionally, another study derived three barriers that impeded pedagogical change within faculty. The three barriers found were (1) lack of training, (2) lack of time, and (3) lack of incentive (Brownell & Tanner, 2012). Focusing on a biology department, researchers looked at three points of contention that faculty may encounter when deciding whether to participate in educational changes. They were "(1) training cultivates a primarily research identity and not a teaching identity, (2) scientist are afraid to "come out" as teachers, and (3) the professional culture of science considers teaching to be lower status than research and positions scientists to have to choose between research and teaching" (Brownell & Tanner, 2012). Because faculty may encounter multiple barriers from a variety of sources, it can be difficult to make pedagogical change and begin to implement active learning strategies.

Importance of peer support in pedagogical change

The effects that faculty peers can have on an individual trying to adopt new innovations in their teaching practices is a component to be considered. Information provided by peers was found to have significance when an individual was forming an opinion about teaching innovation (Rogers, 2003). Additionally, faculty could more quickly form their opinions on new teaching strategies when peer feedback is provided because they may think the experiences of their peers will be similar/relatable to their own (Andrews & Lemons, 2015). Providing faculty with an arena to discuss various teaching strategies is important because evidence supports that peer input/support can influence implementing new strategies.

Faculty learning communities (FLCs) have proven to be a valuable source for peer support and feedback within a university setting. At Miami University, cohort based FLCs which focused primarily on teaching and learning were formed. FLCs discussion topics were chosen based on the needs and desires of the participants. Within the FLCs, faculty were provided opportunities to share and discuss the success, or lack thereof, of different pedagogical techniques and strategies they have tried or want to try. If a strategy was found to be unsuccessful, peers could provide feedback with ideas/changes to improve the strategy. Then the strategy could be re-implemented with the hopes of a successful outcome. Additionally, FLCs provided peer support when trying new strategies instead of becoming deterred by unsuccessful attempts of (Cox, 2004).

Theory of Planned Behavior

The Theory of Planned Behavior is a model used to predict behaviors/actions of an individual and is a modified version of the theory of reasoned action. The modification (Figure 1) is the addition of perceived behavioral control to the theory of reasoned action. The behavioral intention and the behavior (action) is impacted by the perceived behavioral control (Madden, Ellen & Ajzen, 1992). According to the theory of planned behavior, an individual's motivational factors are encompassed by their intentions to influence a behavior. The two motivational factors are (1) how hard they are willing to try and (2) the amount of effort they plan to exert. Their level of intention to implement a behavior, such as active learning strategies in their classroom, can be directly linked to the strength of that intent. Even though behavior is directly impacted by an individual's intention, it is also influenced by non-motivational factors such as availability of opportunities and resources, which can have a negative impact on an individual's performance of the behavior (Ajzen, 1991).

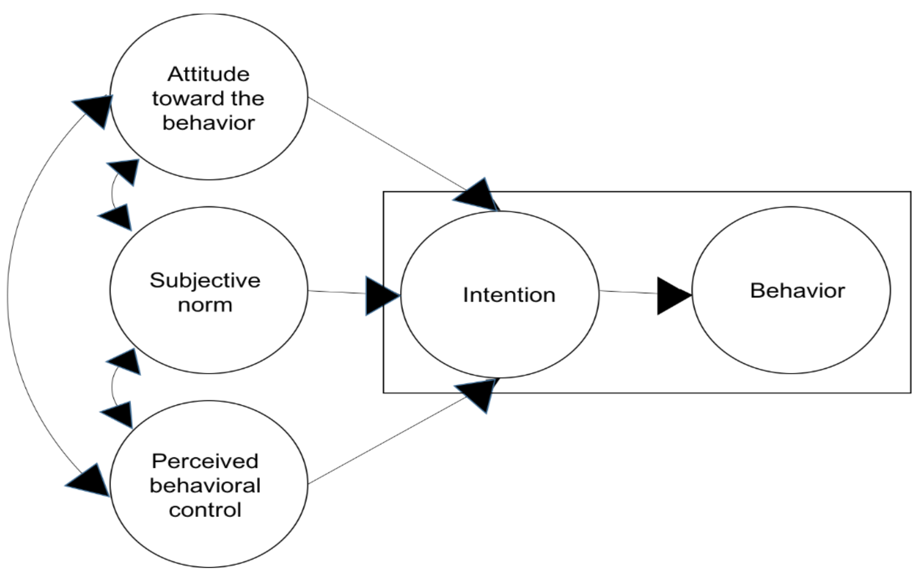

Figure 1. Theory of Planned Behavior

Recently, a study was published that attempted to predict active teaching behaviors in college STEM courses (Semanko, A., Ladbury, J., 2020). The results of the study showed that an instructor's attitude toward the behavior and their perceived behavioral control impacted their intentions to use active learning. They also found that instructor's intentions were a predictor of behavior; i.e. if an instructor's intention were high, they exhibited an increase in their active teaching behaviors. In order to increase active teaching behaviors in STEM courses, a focus on creating positive instructor views on active teaching is essential (Semanko, A., Ladbury, J., 2020).

Misalignment between saying and doing

If a group of STEM faculty intend to implement active learning strategies within their classroom, there should be a measurable difference in how their courses are taught in comparison to traditional lecture-based taught courses. If faculty intend to implement active teaching strategies, these strategies should be reflected in observations of their classrooms (Ebert-May et al., 2011). However, it is suggested that what faculty say they do in their classrooms is not in alignment with their actual classroom practices (Ebert-May et al., 2011). In the Ebert-May study (2011), faculty attended a professional development workshop and were surveyed a year later about their teaching practices. Results of that survey found that 89% of the respondents claimed to have practiced a type of teaching reform that had been presented at the workshop. However, direct classroom observations of study participants illustrated a different picture. A majority of faculty, 75%, continued to have a lecture-based learning environment which directly conflicted with their self-reported data (Ebert-May et al., 2011). The participants claimed to be practicing reformed teaching, but their actions were not aligned as such; hence the misalignment between saying and doing.

Conditions for successful change in a course and an institution

In an extensive study about professional development which spanned across multiple universities and departments, nine factors were found to have critical importance in the success of changes at a classroom level and at an institutional level. These factors include: (1) interactions between different college faculty, (2) support at the collegial and administrative levels, (3) presence of administration, (4) whether a goal is set to be accomplished, (5) establishing a connection to others with a similar goal, (6) building effective interpersonal skills and the trust to facilitate change, (7) planning for cumulative change, (8) partaking in action research, and (9) participating in a group of faculty that collaborates regularly about changes in teaching (Sunal et al., 2001).

Project outcomes

This project aims to determine if there is a presence of a disconnect between what instructors intend to implement and what they implement in the classroom. If there is a disconnect present, determining the contributing factors to this disconnect is a next step. If barriers between intent and implementation can be identified, then it is possible to combat those barriers with future cohorts by using targeted sessions at professional development workshops and various discussions within FLCs.

It is also plausible that faculty are unaware that their intentions and behaviors are misaligned. Showing faculty their classroom observation data, COPUS data, could help them an opportunity to see the misalignment, and in doing so it could potentially close the disconnect, if there is one, between what they intend to implement and what they are implementing within their classrooms.

This project focuses on the direct connection between an individual's intention and their behavior portion of the Theory of Planned Behavior (see Figure 1). Intent encompasses attitudes, norms, and behavioral control, all of which are mentioned in the first research question. Focusing on intent provided a picture as to how those factors combined to influence an individual's behavior. If faculty intend to implement active learning strategies, that intent should be mimicked by their behaviors.

METHODS

Gateways ND participation

This project is compliant with the Gateways ND IRB #SM15263. Opportunity for participation in the Gateways ND program was open to full-time faculty/staff at NDSU who taught at least one course per year. There were 58 interested faculties that applied to the program in Fall 2015, of which 35 were selected based on a pre-determined set of criteria. The criteria included: high enrollment courses, lower level courses, and STEM courses. Selected participants agreed to a two-year commitment to the program which entailed participation in professional development workshops, faculty learning communities (FLCs), classroom observations, completion of various surveys, and sharing artifacts from their course (Callens, V. M., et al., 2014). For this project, data was collected from Fall 2015 to Fall 2016 (Figure 2).

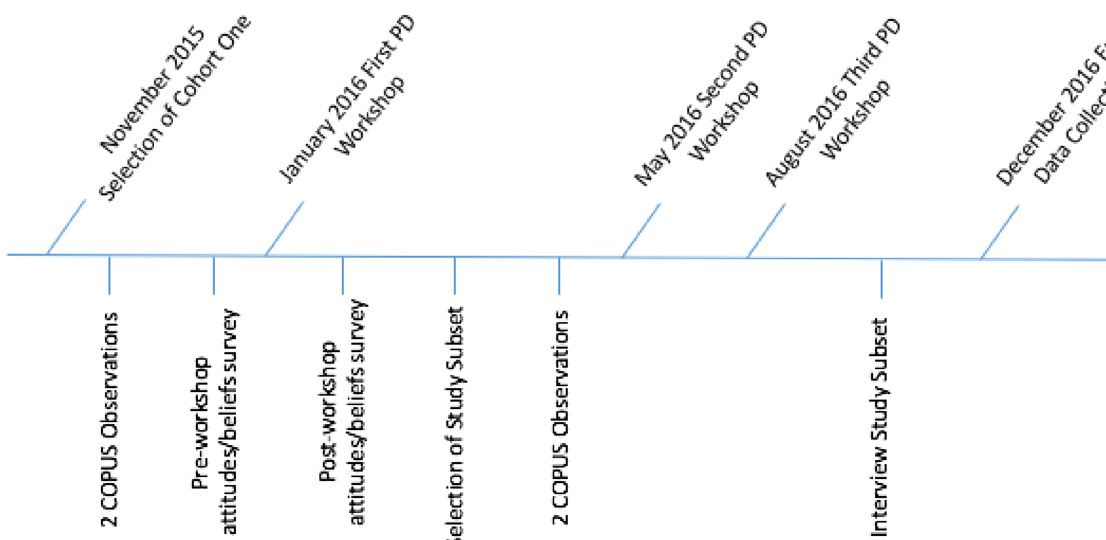

Figure 2. Timeline of study and data collection

Research Question 1

In order to assess the effects faculty attitudes/beliefs have on what/if active learning strategies are used in their classrooms, two different data streams were utilized; the (1) attitudes and belief survey from Fall 2015 and the (2) COPUS data from Fall 2015/Spring 2016.

Attitudes and beliefs survey

An attitudes and beliefs survey was completed by Cohort One, the first group of participants accepted into Gateways ND, prior to receiving any instruction at the first workshop, and once again after the first workshop. The pre/post-workshop survey questions were identical. These self-reporting surveys focused on the beliefs, norms, and perceived behavioral control of the participant and if those components impacted their implementation of pedagogical practices, specifically focusing on active learning. The survey was adapted from an Ajzen and Fishbein survey (1980).

A participant's intent to implement active learning in the classroom (intent score) was determined by their answers to four of the survey questions. These questions asked if the participant intended to implement an active learning strategy within their classroom at some point during the next semester (Table 1). Statistical differences between the pre- and post-workshop intent scores were determined using a two-tailed t-test.

Table 1. Survey questions that compose intent score

Question 1	I intend to use an active learning strategy in the classroom at some time during the next month
Question 2	I plan to use an active learning strategy in the classroom during the next month
Question 3	I want to use an active learning strategy in the classroom at some time during the next month
Question 4	How willing are you to use an active learning strategy in the classroom at some time during the next month

Evaluating classroom environments

The Classroom Observation Protocol for Undergraduate STEM courses (COPUS; Smith et. al 2013) was the assessment tool used during classroom observations (Appendix A). The COPUS allows trained users to observe and characterize what students and faculty do within a class period. Program participants had their classrooms observed by trained COPUS users (graduate students and faculty associated with the Gateways ND project). Exam days were not included in COPUS observations because they would display an inaccurate representation of what happens during a normal day in the classroom (Smith, Jones, Gilbert, & Wieman, 2013).

Using a previous study's collapsed categories for COPUS codes (Smith et al., 2014), data was pulled from Fall 2015 and Spring 2016 observations. Using the collapsed categories provided a simplified way of looking at specific areas. For the purpose of this study, the collapsed category focused on is active strategies of the instructor. The COPUS codes that are combined to create the collapsed category, active strategies of the instructor, are presenting and guiding. Additionally, the student codes for; receiving, talking to class, working, and other were pulled from Cohort 1 COPUS observations for Fall 2015 and Spring 2016. The different categories and their related code descriptions are displayed in Table 2 (Smith et al., 2014). The sections highlighted orange in Figure 4 are focused on in this project.

Table 2. Description of collapsed COPUS codes (adapted from Smith et al., 2014)

Instructor is:	Presenting (P)	Lec: Lecturing or presenting information RtW: Real-time writing D/V: Showing or conducting a demo, experiment or simulation
	Guiding (G)	FUp: Follow-up/feedback on clicker question or activity PQ: Posing non-clicker question to students (nonrhetorical) CQ: Asking clicker question (entire time, not just when first asked) AnQ: Listening to and answering student questions to entire class MG: Moving through class guiding ongoing student work 1o1: One-on-one extended discussion with individual students
	Administration (A)	Adm: Administration
	Other (O)	W: waiting O: Other
Students are:	Receiving (R)	L: Listening to instructor
	Talking to class (STC)	AnQ: Student answering question posed by instructor SQ: Student asks question WC: Students engaged in whole-class discussion SP: Students presenting to entire class
	Working (SW)	Ind: Individual thinking/problem solving CG: Discussing clicker question in groups of students WG: Working in groups on worksheet activity OG: Other assigned group activity Prd: Making a prediction about a demo or experiment TQ: Test or quiz
	Other (OS)	W: Waiting (instructor late, working on fixing technical problems) O: Other

Inter-rater reliability

Observers were trained to use the COPUS by attending multiple one-hour meetings where they viewed training videos and participated in discussions about the meaning of each COPUS code. When COPUS training was complete, observations began. Each Cohort One member was observed twice in Fall 2015 with observers using the COPUS. Each observation had at least two coders present to determine consistency however three observations only had one observer due to scheduling conflicts. Cohen's Kappa was calculated and used to determine the consistency of the observational COPUS data collected between the two observers. An observation was deemed acceptable and consistent if the Cohen's Kappa calculated was between 0.6-1.0. If the Cohen's Kappa was deemed unacceptable, less than 0.6, the observation was removed from the analysis and the class had to be observed an additional time.

Fall 2015 observations served as the baseline data for this project. In Spring 2016, after consistency among observers was shown, the observers could complete observations alone. Several observers completed validation observations during Spring 2016 to re-check inter-rater reliability and verify they are still falling within the accepted Cohen's Kappa range (0.6-1) of acceptable consistency.

Statistical analyses of the COPUS

COPUS data collected from Fall 2015 and Spring 2016 was analyzed using GraphPad Prism 7.03. The data was compiled and compared in a multitude of ways to gain robust results that could lead to possible conclusions of this study or provide direction for future studies.

The different comparisons completed were; 50 minute class Fall 2015 vs. 50 minute class Spring 2016 (for both student activity and instructor activity), 75 minute class Fall 2015 vs. 75 minute class Spring 2016 (for both student activity and instructor activity), combined all student activity and instructor activity (regardless of 50 or 75 minute class) and compared Fall 2015 to Spring 2016, combined all student activity and instructor activity (regardless of Fall 2015 or Spring 2016) and compared 50 minute vs. 75 minute class periods, and 50 minute vs. 75 minute class (for both instructor and student activity correcting for the difference in time period). Time was controlled by keeping the class lengths separate, taking the total number of occurrences per collapsed code and then dividing each code by the maximum potential occurrences (25 times for a 50-minute class, 37 times for a 75-minute class), then combining the values from each semester (Fall 2015 and Spring 2016)Multiple t-tests were used to determine statistical relationships between these comparisons. The correlation coefficient between intent and behavior was determined. Additionally, regression analysis with one predictor was also calculated.

Visual representation of the COPUS

Upon completion of the statistical analyses, boxplot graphs were created to provide visual representations of Cohort 1 COPUS data. Significant differences (if present) were denoted in each of the boxplot graphs using asterisks.

Research Question 2

COPUS data was used to provide evidence of whether faculty are or are not encountering barriers when implementing active learning strategies, and insight into what those barriers might be. To select a subset of participants to interview, the pre/post-workshop attitudes and beliefs survey was utilized.

Determining a correlation between intent score and guiding codes

Looking at Figure 1, a direct correlation between a individual's intent score and their guiding codes (behavior) in their COPUS should be present. Using Excel, a correlation (or lack thereof) between intent score and guiding codes was calculated. If a correlation was found, a linear regression analysis was to be completed.

Study subset of cohort one for Research Question 2

This research question centered around a subset of Cohort One. The subset was selected based on their pre/post-workshop survey answers which indicate the participants intent to implement active learning strategies in January 2016. The faculty first took the survey prior to a

Gateways ND workshops and again after receiving three days of professional development sessions that focused on creating an active learning environment, creating course objectives, and creating assessments to evaluate course objectives. Out of the 35 individuals in Cohort One, six faculty members scored a maximum intent score on both surveys (7/7-100% intent to implement active learning strategies) when asked of their intentions to implement active learning in their classrooms.

Interview protocol

A set of questions was created (Table 3) and three 'practice interviews' were conducted in order to determine if the questions were appropriate and elicited the type of responses desired for this research. Once the questions were vetted and finalized, the subset for this study (n=6) was asked if they would consent to an interview. Consent for interview was needed because it was not a requirement for their Gateways ND participation. Once they agreed to be interviewed, the interviews were scheduled (Fall 2016).

Table 3. Questions developed for interview of study subset

Question 1	How would you describe your teaching career? • Have you taught a variety of courses? • Have you experienced a variety of class sizes? • Have you taught different level courses?
Question 2	How do you approach the course you're teaching? • Are there influences on how you teach a course? (i.e. class size, course level, etc.) • Could you give examples that describe the different approaches?
Question 3	What outside factors influence your instruction decisions? (i.e. peers, collaborators, current research? • If so, what is the most influential?
Question 4	Have you had any other professional development in pedagogical practices prior to Gateways ND?
Question 5	How would you describe your classroom learning environment to a fellow Gateways ND Cohort member?
Question 6	How would you describe an active learning classroom?
Question 7	Are there any barriers you've encountered while trying to implement active learning? • Did they detour you from continuing to implement active strategies?
PROVIDE PARTICIPANTS WITH THEIR FALL 2015/FALL 2016 COPUS DATA	
Question 8	Do you see a change in your COPUS charts? • Change in instructor doing? • Change in student doing? • What do/could you attribute any changes to?
Question 9	Do you think these accurately describe your classroom? • If not, what do you think is incorrect? • What do you do that's not being shown?

FINIDING AND DISCUSSION

Research Question 1

Data collected from the attitudes/belief survey and the COPUS were used to assess if/how faculty attitudes, norms (beliefs about others' beliefs and actions), and personal control beliefs regarding implementing active teaching and learning strategies influence the implementation of them. The participants in Gateways ND were volunteers, which means they were likely receptive to change in pedagogical practices and use active teaching/learning strategies prior to the start of the program. Participants came from different departments across campus and taught various courses, both in level and enrollment numbers (Table 4 & Table 5). This introduced variation within the sample of participants.

Table 4. Cohort One discipline distribution

Discipline	Sciences (physics, biology, chemistry, plant science, etc.)	Social Sciences (business, political sciences, sociology)	Engineering	Education
# of participants	18	6	10	1

Science and technology departments encompassed the majority of Cohort One with 80% of the participants falling into those two disciplines. Additionally, social sciences had good representation within the cohort. A criterion used for selection of program participants was the instruction of lower level courses, however, a lot of participants instructed higher level courses (Table 5). Each semester presented a new array of course levels participants instructed which increased diversity and variation in the data streams.

Table 5. Cohort One course level distributions

Course Level	# participants in Fall 2015 (n=35)	# of participants in Spring 2016 (n=29)	# of participants in Fall 2016 (n=28)
100	7	5	6
200	7	8	7
300	8	7	5
400	13	10	10

The subset of Cohort One contained a varied pedagogical knowledge and previous training/workshops which was determined during their interviews. Some participants contained extensive professional development background while some had little to none prior to their participation in Gateways ND (Table 6).

Table 6. Previous professional development (PD) of study subset

Participant A	PD specifically for teaching strategies (one workshop) Pedagogical luncheons/seminars (@ NDSU)
Participant B	PD specifically for teaching strategies (three workshops)
Participant C	N/A
Participant D	PD specifically for teaching strategies (two workshops) Pedagogical luncheons/seminars (@ NDSU)
Participant E	PD specifically for teaching strategies (one workshop)
Participant F	Pedagogical luncheons/seminars (@ NDSU) Pedagogical oriented sessions at conferences

The desire to participate in a program such as Gateways ND is likely multifaceted. Potential improvements and opportunities provided by the program such as increased student performance, student development of critical skills, and a means to close the achievement gap displayed in many introductory courses (Freeman et al., 2014; Haak, HilleRisLambers, Pitre, & Freeman, 2011; Sivan et al., 2000) could be reasons instructors want to implement active learning in their classroom. In January 2016, Gateways ND participants were instructed at a professional development workshop that provided knowledge that could help create an environment centered around active learning in their classrooms. Participants were introduced to backward design, the importance of alignment between course objectives and assessment, and various methods that could shift the responsibility of learning from faculty to the student (Ebert-May, Brewer, & Allred, 2016; McTighe, Seif, &Wiggins, 2004).

Participants' intent was the focus of this research question because we sought to identify influences on an instructor's intent to implement active learning (Ajzen, 1991). Cohort One exhibited diverse pre/post-workshop survey intent scores but calculating a two-tailed t-test showed no statistical difference between the two samples *(*Figure 3. p=0.189).

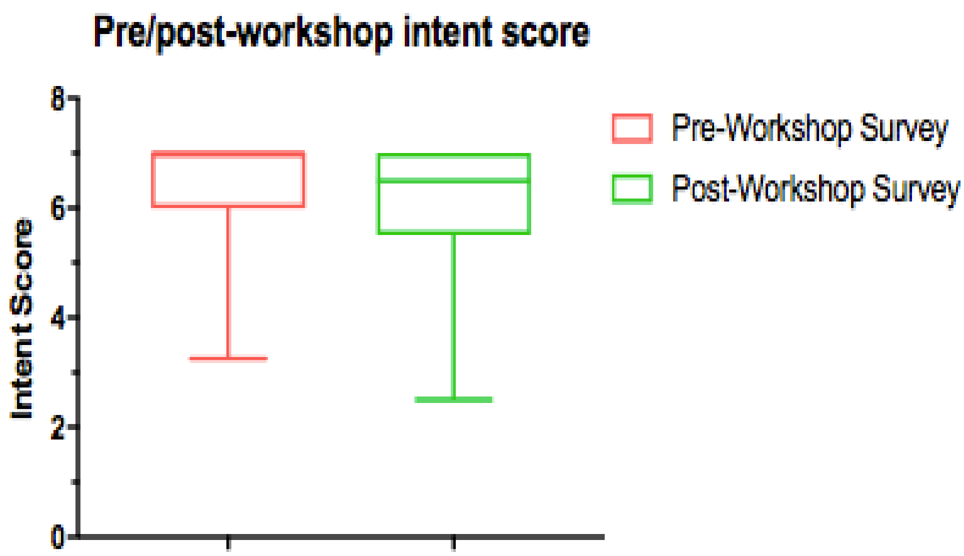

Figure 3. Pre-workshop/post-workshop survey intent scores for Cohort One

The lack of change in intent score between pre/post-workshop surveys could be in part to a ceiling affect (maximum value for intent score is 7). Prior to participants beginning Gateways ND, a majority had a very high intent to implement active learning strategies in their classroom. Because participants volunteered to be part of this program, the intent to implement active teaching strategies was high even pre-workshop.

Because there was no significant difference in pre/post-workshop survey intent scores (already at a high intent score), one would expect the Cohort's COPUS data from Fall 2015 to Spring 2016 follow that trend in that faculty would, in fact, display in increase in active strategies. If faculty have a high intent to implement active strategies, it should be reflective in their classroom observations. Using the collapsed COPUS codes described in Table 2 (Smith et al., 2014), several comparisons were made to try and determine if there were differences between Fall 2015 and Spring 2016 observations, specifically looking at whether length of class impacted the implementation of active learning.

Statistical differences were found in the COPUS data from the courses that had a class length of 75-minutes. Student activity changed in two out of the four collapsed codes. The amount of time students were 'receiving' and 'talking to class' was statistically significant (Figure 4B; $p<0.0001$ and $p<0.0001$, respectively). Focusing on instructor activity, there was a significant increase in the amount of guiding time from Fall 2015 to Spring 2016 (Figure 4D, $p<0.0001$). This could be attributed to a multitude of reasons. One reason could be that faculty may have felt like they had more time and opportunity to implement active strategies. It is also possible they learned new strategies at the January workshop that they implemented during the spring semester.   However, looking at the student activity data paints a different picture. Even though instructors increased their guiding codes, the student activity data does not reflect that change.

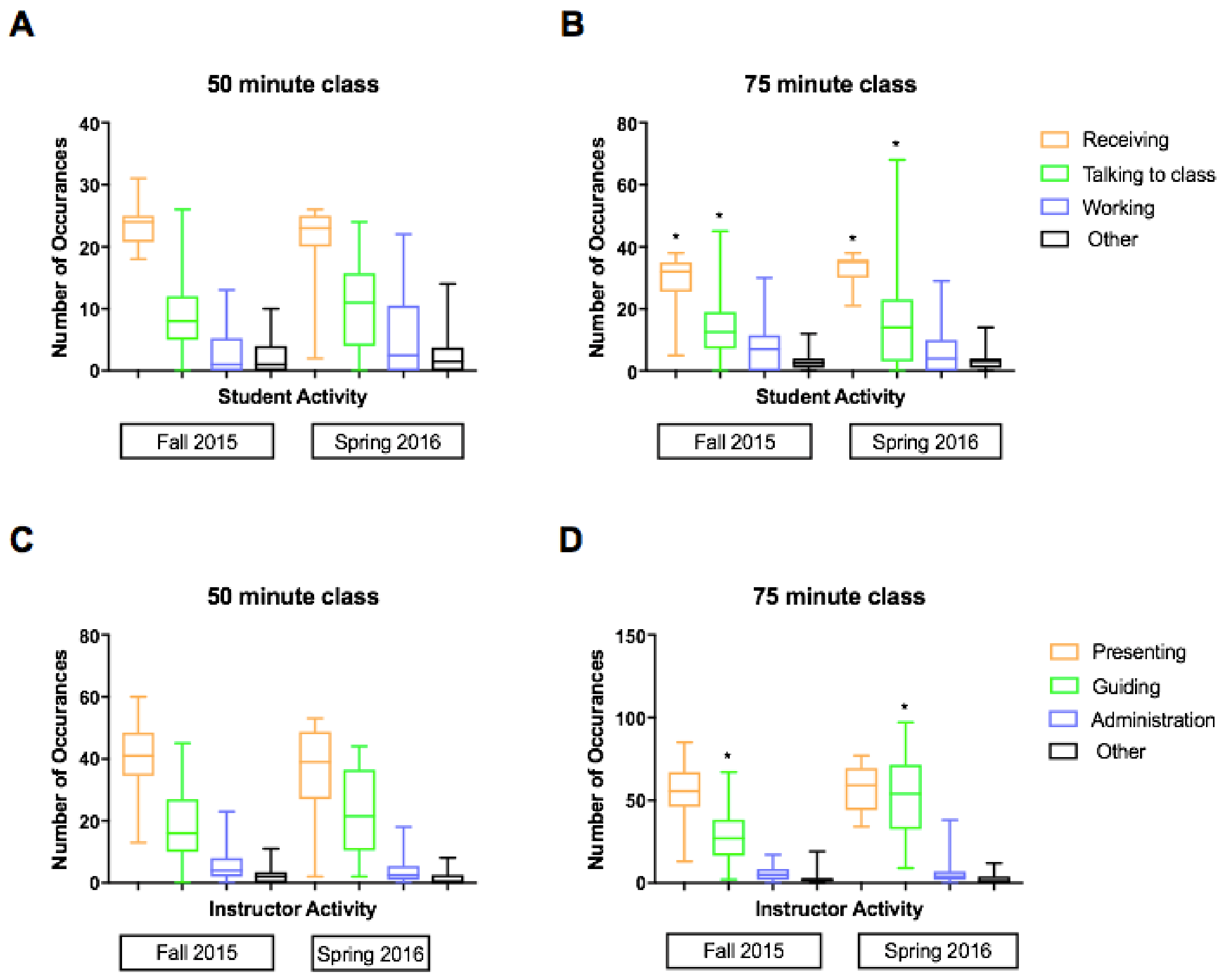

Figure 4. A. Comparing Fall 2015 vs. Spring 2016 student activity in a 50-minute class. B. Comparing Fall 2015 vs. Spring 2016 student activity in a 75-minute class. C. Comparing Fall 2015 vs. Spring 2016 instructor activity in a 50-minute class. D. Comparing Fall 2015 vs. Spring 2016 instructor activity in a 75-minute class.

Most participants intended to implement active teaching strategies; however, their students are still 'receiving' (being talked to/at) for a large portion of their time in the classroom. This suggests a possible misalignment between faculty intent and behavior (Ebert May et al., 2011). Although we see students with a high level of receiving, that receiving may be a result of student interactions (student presenting, talking to class, etc.)

There was a significant change in instructors use of guiding codes from pre-workshop to post-workshop when looking at 75 minutes class periods. The types of active teaching strategies being utilized in the classroom did not change, there was simply an overall increase in the use of these strategies (i.e. clicker questions, think-pair-share, and in class discussions).

The next analysis combined all student and instructor activity (regardless of class length) data from Fall 2015 to Spring 2016 and compared the two semesters.

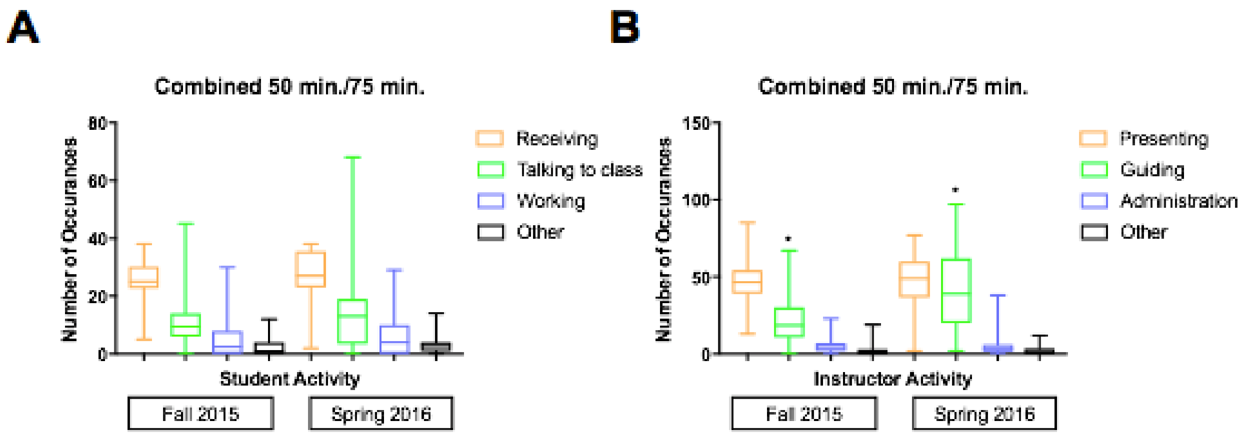

Figure 5. A. Comparing Fall 2015 vs. Spring 2016 student activity when combining all observations. B. Comparing Fall 2015 vs. Spring 2016 instructor activity when combining all observations.

No statistically significant differences in student activity between Fall 2015 and Spring 2016 were found, which is consistent with the lack of change exhibited in faculty's pre/post-workshop survey intent scores (Figure 3). Since faculty displayed no change in their intent, it is fitting that there was no change in student activity. Nevertheless, even with that lack in faculty intent change, there was a significant change in their behavior, specifically their use of guiding codes (Figure 5B. $p<0.0001$). This could be attributed to the exposure to active learning strategies that Cohort One was exposed to during the first Gateways ND workshop.

The last analysis compared activities in a 50-minute class period versus 75-minute class periods to assess changes between pre- and post-workshop implementation.

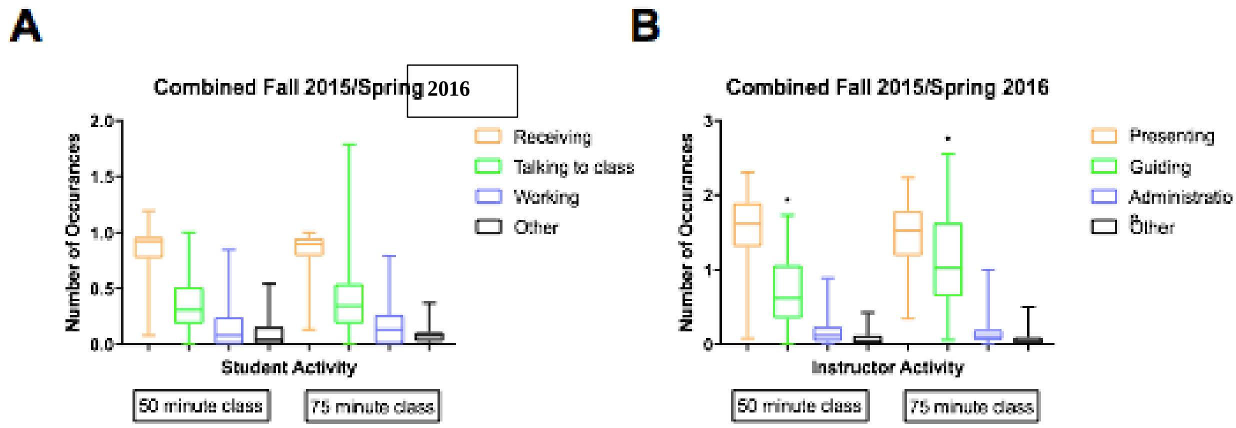

Figure 6. A. Comparing 50-minute class vs. 75-minute class student activity when combining all Fall/Spring observations. B. Comparing 50-minute vs. 75-minute class instructor activity when combining all Fall/Spring observations.

Once again, the only significant difference found was in the guiding codes an instructor used (Figure 6B, $p<0.0001$). It is commonly thought that active learning ‘takes too long’, so perhaps providing faculty with longer class periods would provide more opportunities to implement active learning strategies (Michael, 2007; Brownell & Tanner, 2012).

Because the guiding code was found to be statistically significant, a correlation between an individual’s intent and their guiding codes was proposed. A moderate correlation was found between a participant’s post-workshop intent score and their COPUS guiding codes from Spring 2016 ($\rho(xy)=0.4507$ for $n=29$). This suggests that an individual’s intent directly influences their exhibited behavior, which supports the Theory of Planned Behavior (Ajzen, 1991).

Because there was a significant correlation between intent and behavior, a regression analysis with one predictor was calculated (Figure 7). An R^2 of 0.2 (20%) was calculated and then a regression equation of “0.25(intent score)-0.553=predicted ‘guiding’ codes” was determined. This means that using the intent score of a participant, we can determine 20% of variance in all their guiding codes.

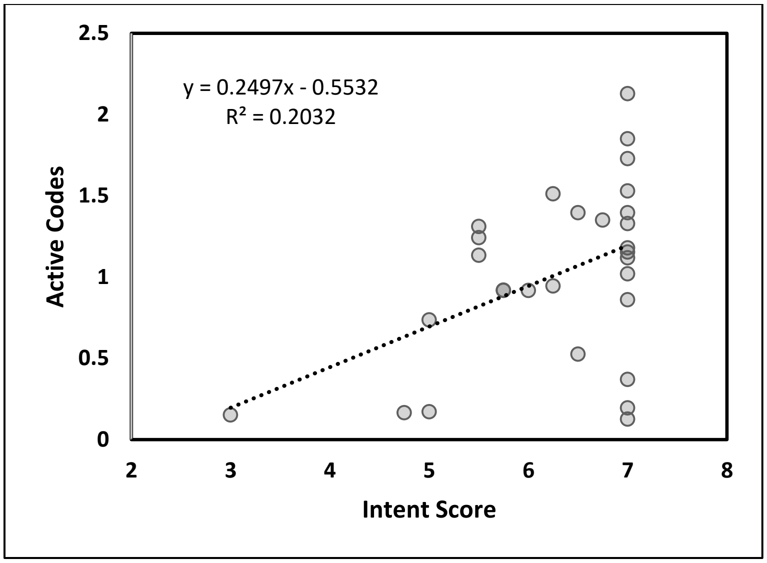

Figure 7. Linear regression analysis of post-workshop intent score and Spring 2016 COPUS data active codes. Each point represents the average reported intent score for each participant in response to the four intent questions asked in the post-workshop attitudes and beliefs survey in relation to the active codes recorded in their spring classroom observations.

When using humans as research subjects, having an R^2 that substantial is a rarity because human behavior is highly variable, unpredictable, and changes frequently. In studies that have humans as a study subject, being able to predict any amount of their actions is impressive and substantial. If predicting participants guiding codes is possible, the Gateways ND research team can pinpoint the participants that would be less likely to incorporate active learning strategies and provide additional help and resources which may encourage them to change and implement new strategies within their classrooms.

Overall, we can say that the COPUS data can be used to say that there was reformation, to some extent, in participant classrooms from Fall 2015 to Spring 2016.

Research Question 2

The attitudes and beliefs survey was used to artificially select a subset of participants to interview. My goal was to determine if faculty are encountering barriers when implementing active learning strategies and what are those barriers are. Interviews could potentially lead to more detailed, in-depth information to support the claims of this research question. Interviews also provided the chance to discuss teaching beliefs, teaching experiences, pedagogy, and to provide feedback for both the interviewer and interviewee. Research question 1 exhibited that even if faculty intend to implement active learning strategies, it is not necessarily being reflected in their COPUS observations. If the active strategies are not being reflected in their observations, it is plausible that Gateways ND participants are encountering barriers when implementing active learning strategies in their classroom. If the barriers can be identified that information could be used to help benefit other program participant's/future members. In order to ascertain possible barriers, interviews of the subset were conducted.

All interviews were audio recorded, transcribed and made anonymous. After thought and discussion, using excerpts from the interviews could be more beneficial to this study instead of coding the interviews. Grounded theory could not be used to find emerging themes in the interviews because of the way the questions were written. The questions prompted interviewees for specific answers, so it was known *a priori* what kind of answers would likely be received for each question. Interview transcripts were given with syntax as interpreted from the audio recordings. Diction and punctuation were adjusted based on interpretation. Questions three and seven revealed the most insightful responses concerning support structures and barriers to implementation which supported the two hypotheses stated in the introduction of this study; peer support is important when implementing new teaching strategies and faculty are encountering barriers to implementing active learning strategies.

Importance of peer support

When asked about outside factors that influence their instructional decisions, a common theme that emerged was their peers and their department are positive attributors to their decisions, which supports the second hypothesis of this study.

> *"Yes, definitely I think that the environment in this department is really supportive of the new and alternative techniques. And so that has really influenced my desire to try them knowing that people feel positively toward that."*

Participant B stated the importance the departmental environment has in affecting an individual's desire to try new techniques in the classroom. Knowing that their department supports new strategies and thinks positively about them could increase faculty members interest in learning about the new strategies and more willing to implement them. The positive environment of the department influenced their opinion of the new and alternative strategies, which supported previous studies (Rogers, 2003).

> *"You know I like to bounce ideas off of them, I like to hear what they're doing in their class and see whether it's something I can directly use or something that I can, you know, 'Oh, I can do a similar type of activity'."*

This quote from Participant E is a good illustration of the affect peers can have on instructional decisions. They are using their peers as a feedback tool in how they are using active learning strategies and possibly taking said strategies and using them in their own classroom. Using an activity developed by a peer saves the time of having to create something themselves. Collaboration means they do not have to 'reinvent the wheel' which saves time and resources. He is taking the experience of his peers into consideration when implementing certain activities and that their experience may be similar to his own (Andrews & Lemons, 2015).

> *"Because all the institutions I've been at… were all very supportive of the active engagement style of doing things and knew that it worked and just kind of embraced it… I would have wanted to do that stuff, but I don't know if I actually would have if the whole department would have been like 'EHH don't do that so'"*

Participant A discussed the importance of support at an institutional level when they try new active teaching strategies (Sunal et al., 2001). They even stated that they would have thought about not attempting the active learning strategies if the institution was not supportive of the change from traditional lecture. Having an institution that is promoting change in the classroom can influence one's desire to make the change for a variety of reasons. Reasons could be to better teach their students, or consideration of job security if they don't go along with the institutional push for implementing active learning strategies.

> *"…we give each other feedback on our teaching styles and problems we're having but also often kind of workshop them together."*

The above quote from Participant C is a depiction of how peer feedback can affect what teaching strategies faculty implement. The participant was an active member of a faculty learning community (FLC) set up by the program which gave them an arena to have discussions about teaching (Cox, 2004). Discussion with peers is a chance to work through any troubles they have had implementing different strategies and gives them an opportunity to make modifications in order to attempt it again. Peer feedback is a good way to work through issues with a strategy. They could offer a new perspective that may not have been thought about prior to discussion.

The importance of peer support in pedagogical change found in this study is in agreement with prior findings (Rogers, 2003; Andrews & Lemons, 2015). This provided evidence for the need of support and positive attitude at the peer, department, and institution level when faculty assess whether to make the change from a traditional lecture to an active learning classroom. It was mentioned that a lack of support may keep faculty from making the change that is needed to reform STEM education (Bybee, 2010; Fairweather, 2010; Goldweather & Harvey, 1983).

Barriers to implementing active learning strategies

Having a subset of participants with 100% intent to implement active learning in their classrooms but lacked evidentiary change from Fall 2015 to Spring 2016, determining possible barriers affecting their implementation could lead to possible explanations for the absence of change in congruence with the first hypothesis of this study. One barrier discussed in an interview was lack of time to prepare for a class or to grade assignments.

> *"There are obstacles, I don't know how obstacles are different than barriers, so some of the difficulties are just kind of teaching prep time. Since I'm working with a class or different classes that I've taught for 5 or 6 years then switching it to even more active learning then is you know prepping all new materials um including new assessments and other things like that. So, I think that's the main obstacle or barrier."*

Participant F identified one barrier they have encountered, prep time (Michael, 2007). Changing the active strategies they have been using in the classroom for multiple years would lead to the investment of more time being invested in the preparation time. The creation of extra work and the increased time investment could deter faculty from making the change from a traditional lecture to an active learning classroom. Finding the time to make new plans and activities is an additional burden to the large workload most faculty already have. This supports the claim that time is a critical component when making instructional changes (Brownell & Tanner, 2012).

> *"I think time for me is the biggest barrier because it really takes a lot of time to figure out how you're going to do an activity and what that activity is going to be. And I think that it's hard no matter what you teach. Sometimes I think it's a little bit harder in the upper level electives because there really isn't any stock material that you can get. There's a lot of great stuff for entry-level material that's online and so even for my evolution class I use some of that intro level material even though it's sometimes a little bit simple and it doesn't work as well."*

Another interviewee touched on the difficulty of preparing new activities. She said it was easier to try new things in a lower level course because there is a variety of stock materials already available. Using an activity that someone else has designed saved time because they did not have to create their own activities (Michael, 2007).

A second barrier identified was the setup/layout of the classroom. The subset taught in a variety of classrooms; from traditional lecture halls to SCALE-up classrooms. NDSU now has access to multiple SCALE-UP classrooms on campus. SCALE-UP classrooms help facilitate and encourage active learning. Students are seated at round tables with 9 chairs and the instructor podium is at the center of the classroom. White boards, projectors, and televisions are located all around the room which students can easily interact with. SCALE-UP makes it easier for both students and instructors to be active by moving around, being hands on, and being interactive with one another (Beichner et al., 2007). Multiple Gateways ND participants have had the opportunity to teach or have taught in a SCALE-UP classroom during their 2 years within the program.

> *"I feel like when they are sitting and facing each other they're much more willing to talk to each other because they're facing each other. It was really hard before when they were just 4 across to get them to really talk because they weren't looking at each other."*

This is an excerpt taken from Participant B. She now teaches in a SCALE-up classroom, but before the availability of the new classrooms, she was teaching in a traditional lecture hall classroom. This quote illustrated that having a setup where students can easily interact with each other makes group work easier to implement, and it makes students more willing to engage with each other.

> *"Like the room I'm in is the standard kind of lecture hall. It's a nice standard lecture hall but it's still a standard lecture hall. And I'd like to do, I think it would be easier for students to work together on longer problems if we had space like in the SCALE-up room where there was tables that they could collaboratively work together rather than in kind of these fix chairs that they can't move in."*

Participant A would prefer to teach in a SCALE-up room because he thinks it would help students engage with each other and work collaboratively on problems. He points out the importance of having the ability to be mobile in the classroom.

> *"I do think that it makes it difficult for students to get in groups, you know sit around a table and do things."*

This quote is an example of the difficulty of teaching in a traditional lecture hall. They stated that yes, active learning and group work can still be implemented, but the classroom setup makes it more challenging.

A third barrier established was the student population itself (Michael, 2007). There is a variety of students and the student body demographics change every semester (for the most part).

> *"Students, I mean, students definitely can be. Again, they're, students themselves are… well your student body is quite variable, right? There's that whole argument against a person vs. people, right? As an individual I think it's, you can't get through to everybody but as a class, sometimes when people get together, they just become more stubborn than when they are alone. "*

This quote from Participant E is an example of issues students can present. Managing the change in variation and diversity of students every semester means that faculty need to frequently adjust to align with their students. Faculty D said he gives a survey at the beginning of each semester to assess the demographics of his students and what knowledge they are coming into the class with, but he did not think students were a barrier to implementing active learning strategies.

> *"Yeah, I mean there have been classes or activities where students just don't want to engage."*

At some point in time during the semester, it could be assumed that most faculty come across a day where the students do not want to engage in what is being done in the classroom. Being able to maintain structure during those 'days' is important for faculty and for keeping their students on track.

A topic that materialized was the importance of establishing classroom culture early in the semester, so students know what to expect. Letting students know what the expectations are right away is important.

> *"I know my first class I don't do anything. I don't like to lecture, I don't like to go over the syllabus, and I like to get the students up and moving. And, so like, if I feel like through that you know the student's kind of learned that from the first class onwards because this is the way it's going to be."*

Significance of setting the classroom culture was discussed by multiple participants. Some said they struggle with it, but they have modified their actions to show students what their expectations are.

In contrast to the excerpts about barriers, Participant C and Participant D stated they had not encountered barriers to implementing active learning strategies. Faculty D stated that he was 'stubborn' and would not let anything deter his instruction in the classroom. Faculty C talked about setting the classroom culture and expectations right away and in doing so she had never experienced a barrier.

To give a general summary of what was found in the interviews, Table 7 was developed. The X's represent the presence of said category in the interview. A blank box indicates the absence of that category within the interview. Four out of six faculties in the subset have had experience teaching in a variety of course levels in addition to a diversity in enrollment numbers.

The answers given by the participants about barriers and the importance or peer support are in agreeance with previous studies (Andres & Lemons, 2015; Cox, 2004; Rogers, 2003; Sunal et al., 2001). Gateways ND provided faculty with workshops about active learning and created an environment to foster new ideas, discuss potential issues, and provide feedback to faculty members along with monthly FLCs to continue the discussion of pedagogical practices.

Table 7. General summarization of interview results. “X” indicates positive participant answer.

Participant	Have taught a various course levels/enrollment size		Course level/enrollment numbers influences instructional decisions		Factors influence their instructional decisions			Experienced barriers to implementation of active learning strategies
	Course level	Enrollment size	Course level	Enrollment	Literature	Peers	PD	
A	X	X		X	X	X	X	X
B	X	X		X	X	X		X
C	X		X		X	X	X	
D		X		X	X			
E	X	X			X	X	X	X
F	X	X		X		X	X	X

CONCLUSIONS

According to the Theory of Planned Behavior, there are three factors that attribute to an individual's intent to exhibit certain behaviors; attitudes towards the behavior, subjective norms, and perceived behavioral control. If an individual intends to do something, there should be a direct correlation to their behavior. We focused on Gateways ND participants intent to implement active learning strategies and their actions in their classrooms. Although most participants had intentions to implement active strategies, that intent was not necessarily reflected in their actions. There was no significant change in participant intent scores pre/post workshop, but that could potentially be due, in part, to a ceiling effect. However, there was a significant increase in an instructor use of 'guiding codes' which infers an increase in active strategies being utilized in the classroom from Fall 2015 to Spring 2016. Additionally, there was a significant correlation ($\rho(xy)=0.4507$ for $n=28$) found between intent score and guiding codes in the Spring 2016 COPUS data. With the significance found, we can suggest that an individual's intent is significantly correlated to their behavior, which supports the Theory of Planned Behavior.

Based on the COPUS observations, we found that there is not always an alignment between an instructor's intent and their behaviors when it comes to implementing active strategies in their classroom. Even though we saw an increase in instructors 'guiding codes', we did not see a parallel shift in student activity. This misalignment can be attributed to a multitude of factors such as influences on instructional decisions and barriers to implementing active strategies. Through interviews with a subset of Cohort 1 participants, we were able to determine three influences on instructional decisions and three barriers to active strategy implementation.

The three influencers on instructional decisions are peers, the department, and the institution. Participants found that peer feedback can affect what teaching strategies faculty choose to implement in their classrooms. Using FLCs, participants were given an arena to have discussions about teaching strategies/methods and whether they were successful (Cox, 2004).

> *"…we give each other feedback on our teaching styles and problems we're having but also often kind of workshop them together."*

The importance of peer support in pedagogical change found within this study agrees with prior findings (Rogers, 2003; Andrews & Lemons, 2015). Participants mentioned that a lack of support from peers may deter them from making the change that is needed to reform STEM education (Bybee, 2010; Fairweather, 2010: Goldweather & Harvey, 1983). The next influencer determined is the department the faculty member is a part of. An interviewee said that the positive environment within their department had an influence on their opinion of the new and alternative strategies which supports previous research (Rogers, 2003).

> *"You know I like to bounce ideas off of them, I like to hear what they're doing in their class and see whether it's something I can directly use or something that I can, you know, 'Oh, I can do a similar type of activity'."*

Lastly, the attitude of the institution can influence faculty opinions on teaching reform and whether a change in their teaching styles should take place which aligns with previous findings (Sunal et al., 2001).

> *"Because all the institutions I've been at… were all very supportive of the active engagement style of doing things and knew that it worked and just kind of embraced it… I would have wanted to do that stuff, but I don't know if I actually would have if the whole department would have been like 'EHH don't do that so'"*

Our participants identified three barriers to implementing active strategies; time, classroom setup, and the student population. The amount of prep time can increase when utilizing active strategies, but time was only mentioned as being a barrier by one of the interviewees.

> *"I think time for me is the biggest barrier because it really takes a lot of time to figure out how you're going to do an activity and what that activity is going to be. And I think that it's hard no matter what you teach. Sometimes I think it's a little bit harder in the upper level electives because there really isn't any stock material that you can get. There's a lot of great stuff for entry-level material that's online and so even for my evolution class I use some of that intro level material even though it's sometimes a little bit simple and it doesn't work as well."*

The second barrier mentioned by Gateways ND participants is the classroom setup.

> *"I feel like when they are sitting and facing each other they're much more willing to talk to each other because they're facing each other. It was really hard before when they were just 4 across to get them to really talk because they weren't looking at each other."*

At NDSU, there are now several SCALE-UP classrooms which help alleviate some of the physical constraints a classroom can pose (Beichner et al., 2007).

> *"Like the room I'm in is the standard kind of lecture hall. It's a nice standard lecture hall but it's still a standard lecture hall. And I'd like to do, I think it would be easier for students to work together on longer problems if we had space like in the SCALE-up room where there was tables that they could collaboratively work together rather than in kind of these fix chairs that they can't move in."*

However, traditional classrooms are still the predominant classroom setup at NDSU and the difficulty of using these rooms with active strategies was discussed by many participants.

The third barrier identified was the student population. The student population is an everchanging variable (Michael, 2007). One interviewee described the difficulty in continuously adapting to the students in their classrooms from one semester to the next.

> *"Students, I mean, students definitely can be. Again, they're, students themselves are… well your student body is quite variable, right? There's that whole argument against a person vs. people, right? As an individual I think it's, you can't get through to everybody but as a class, sometimes when people get together, they just become more stubborn than when they are alone. "*

By identifying instructional influencers and perceived barriers to pedagogical change, we can correct the misalignment between an individual's intent to implement active strategies and their behavior. If we can ensure instructors have platforms which support teaching reforms and help eliminate barriers to implementing active strategies, it will help drive the reform that is needed in STEM education.

LIMITATIONS

Like most research, there were many plausible limitations within this study. These limitations include small sample size (n=35 and n=6), number of observations performed on Cohort participant classrooms, the tool utilized in those observations (COPUS), the artificial selection of the interview subset, and the self-selection of the participants into the program.

The first limitation was the small sample size available to work with. There was a maximum of 35 participants teaching per semester, and during the spring 2016 and fall 2016 semesters there were numerous participants that did not teach a course, or they did not teach an observable course. Once the participant intent score was selected as the determining factor of the subset, only six participants were left within that subset. Having small sample sizes makes statistics on quantitative data difficult but using interviews as a qualitative tool helps support the findings of this study. Having artificially selected subset is also a drawback. There were no statistics available to determine if choosing a participant with an intent score of 7 is significantly different than choosing a participant with an intent score of 6, or 6.5. Not having justification in support of the method used to artificially select the subset is not ideal.

Other limitations we encountered are the number of observations performed each semester and the utilization of the COPUS for those observations. It is unknown whether two observations of a class period within a semester (approx.16 weeks) provides an accurate picture/dialogue of what is occurring. The use of the COPUS is highly subjective regarding the meanings of the codes and, potentially, two observers could viewing/recording the same class period very differently. We tried to combat this by monitoring inter-rater reliability for each observation, but with a minimum 60% code alignment between the observers could result in a high discrepancy between the observers. As a research group, it was agreed upon to not utilize the ‘student engagement’ category of the COPUS. Not using this category of codes gave rise to the possibility that faculty are using active learning strategies, but students are not engaging with them. Furthermore, it is possible that the COPUS was not the ideal tool for Gateways ND, as it was designed for STEM courses. Not all of Cohort 1 participants taught STEM courses; can the COPUS accurately capture what is happening in non-STEM courses?

Furthermore, an additional limitation is the self-selection of individuals into the program. The participants have volunteered to be a member of the program, meaning they might already be invested in using active learning strategies and transforming their teaching. Taking that into consideration, this study may not provide an accurate representation of what is occurring within the university.

Another limitation is not identifying what a ‘reformed’ classroom is. There is no previous research that concludes what an ideal active learning classroom resembles or what the ideal COPUS data is. Previous studies have shown that moving the responsibility of learning to the student instead of the instructor is a way to shift from a didactic classroom to an active classroom. Increasing active strategies is, by proxy, increasing student engagement. The data collected in this study shows an increase in students partaking in active strategies (i.e. answering instructor posed questions, asking the instructor questions, engaged in whole-class discussion, or presenting to the class). This would suggest there was reform in the classrooms to some extent. But without having knowledge of what a reformed classroom is, we are unable to explicitly say whether reformation has occurred. So even though we saw a change from pre-workshop to post-workshop COPUS data, we cannot say that this, in fact, shows a reformed classroom. We can state there is evidence which supports reformation but can make no concrete statements.

FUTURE DIRECTIONS

This study could lead to a plethora of future studies. One direction would be the introduction of diversity within the sample and eliminate the self-selection. A randomization of cohort participants could lead to more interesting results and classroom observations. Having faculty members in Gateways ND that did not volunteer may be more stubborn in terms of adopting new ideas and teaching strategies. There is potential that they could not want to change or see the need to change their teaching practices.

It would be interesting to see the correlation between course type and active learning methods. If correlations were identified they could be used to determine if different instructors, courses, or departments implement variable alternative strategies. If there are strategies that are easily modified to fit certain courses, faculty, or departments, we could use that information to target specific audiences in future studies.

Administering a pre-program survey and post-program survey to determine what participants know about active learning strategies would be a method of validating the Gateways ND program. If we can show evidence that faculty leaving the program have learning gains as a result from their participation in Gateways ND, it could be used to validate the importance of the program, as well as illustrating the importance of making professional development workshops and FLC opportunities available to all faculty on campus.

BROADER IMPACTS

Gateways ND leaders could use this knowledge to inform future workshops. They could look at what barriers their participants have been presented with and then form workshops to help them combat the barriers. Universities are vastly different in faculty demographics and student diversity, so knowing what our faculty community is dealing with is helpful when trying to make a campus-wide push for changing from traditional lecture to active learning classrooms.

REFERENCES

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Ajzen, I. (1991). The theory of planned behavior. *Orgnizational Behavior and Human Decision Processes*. *50*, 179–211. http://doi.org/10.1016/0749-5978(91)90020-T

Andrews, T. C., & Lemons, P. P. (2015). It's Personal : Biology Instructors Prioritize Personal Evidence over Empirical Evidence in Teaching Decisions. *CBE-Life Sciences Education, 14*, 1–18. http://doi.org/10.1187/cbe.14-05-0084

Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J. J., Deardorff, D., Allain, R. J., … Risley, J. (2007). The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project Abstract. *Physics*, *1*(1), 1–42. Retrieved from http://www.percentral.com/PER/per_reviews/media/volume1/SCALE-UP-2007.pdf

Bonwell, C., Eison, J. (1991). Active Learning: Creating Excitement in the Classroom. ASHE-ERIC Higher Education Report. ERIC Publications.

Brown, B. R., Brown, J., Reardon, K., & Merrill, C. (2011). Current Perceptions. *Technology and Engineering Teacher*, (March), 5–10.

Brown, J. (2012). The Current Status of STEM Education Research. *Journal of STEM Education, 13*(5), 7–12.

Brownell, S. E., & Tanner, K. D. (2012). Approaches to Biology Teaching and Learning Barriers to Faculty Pedagogical Change : Lack of Training , Time , Incentives , and . . . Tensions with Professional Identity ?. *CBE-Life Sciences Education, 11*, 339–346. http://doi.org/10.1187/cbe.12-09-0163

Bybee, B. R. W. (2010). Advancing STEM Education : A 2020 Vision. *Technology and Engineering Teacher,* (September), 30–36.

Callens, V. M., Kelter, P., Motschenbacher, J., Nyachwaya, J., Ladbury, L., Semandko, A. (2019). Developing and implementing a campus-wide professional development program: Successes and challenges. Journal of College Science Teaching, 49(2), 68–75.

Couch, B. A., Brown, T. L., Schelpat, T. J., Graham, M. J., Knight, J. K. (2015). Scientific Teaching: Defining a Taxonomy of Observable Practices. *CBE-Life Sciences Education,* 14(9), 1-12. https://www.lifescied.org/doi/pdf/10.1187/cbe.14-01-0002

Cox, M. D. (2004). Introduction to Faculty Learning Communities. *New Directions for Teaching and Learning,* (97), 5-23.

Ebert-May, A. D., Brewer, C., & Allred, S. (2016). Innovation in large lectures-teaching for active learning. *BioSciences, 47*(9), 601–607.

Ebert-May, D., Derting, T., Hodder, J., Momsen, J., Long, T., & Jardeleza, S. (2011). What We Say Is Not What We Do: Effective Evaluation of Faculty Professional Development Programs. *BioScience*, *61*(7), 550–558. http://doi.org/10.1525/bio.2011.61.7.9

Fairweather, J. (2010). Linking Evidence and Promising Practices in STEM Undergraduate Education: A Status Report for the National REsearch Council Board of Science Education.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *PNAS Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410–8415. http://doi.org/10.1073/pnas.1319030111

Goldberg, M., Harvey, J. (1983). A Nation at Risk: The Report of the National Commission on Excellence in Education. *The Phi Delta Kappan, 65*(1), 14-18.

Haak, D. C., HilleRisLambers, J., Pitre, E., & Freeman, S. (2011). Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology. *Science*, *332*(6034), 1213–1216. http://doi.org/10.1126/science.1204820

Handelsman, J., Ebert-may, D., Beichner, R., Bruns, P., Chang, A., Dehaan, R., … Wood, W. B. (2010). POLICY, *304*(5670), 521–522.

Labov, J. B., Singer, S. R., George, M. D., Schweingruber, H. A., & Hilton, M. L. (2009). From the National Academies Effective Practices in Undergraduate STEM Education Part 1 : Examining the Evidence. *CBE-Life Sciences Education*, *8*, 157–161. http://doi.org/10.1187/cbe.09

Madden, T., Ellen, P., Ajzen, I. (1992). A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action. *Psychology and Social Psychology Bulletin,* 18(1), 3-9.

McTighe, J., Seif, E., & Wiggins, G. (2004). You Can Teach for Meaning. *Educational Leadership, 62*(1), 26–31.

Merrill, C. (2009) The future of TE masters degrees: STEM. Presentation at the 70th Annual International Technology Education Association Conference, Louisville, Kentucky.

Michael, J. (2007). Faculty Perceptions About Barriers to Active Learning. *College Teaching*, *7555*(January). http://doi.org/10.3200/CTCH.55.2.42-47.

Pollock, P. H., Hamann, K., Wilson, B. M. (2011). Learning Through Discussions: Comparing the Benefits of Small-Group and Large-Class Settings. *Journal of Political Science Education,* 7(1), 48-64.

Rogers, E. M. (2003). Elements of diffusion. *Diffusion of innovations*, *5*, 1-38.

Robertson, K. (2006). Increase student interaction with "ThinkPair-Shares" and "Circle Chats". Colorin: Colorado. Retrieved from http://www.colorincolorado.org/article/13346

Semanko, A. M., Ladbury, J. L. (2020). Using the Reasoned Action Approach to Predict Active Teaching Behaviors in College STEM Courses. *Journal for STEM Education Research.* https://doi.org/10.1007/s41979-020-00038-8.

Sivan, A., Leung, R. W., Woon, C. C., Kember, D. (2000). An implementation of active learning and its effect on the quality of student learning. *Innovations in Education and Training International*, *37*(February), 381–389. http://doi.org/10.1080/135580000750052991

Smith, M. K., Jones, F. H. M., Gilbert, S. L., & Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Instrument to Characterize University STEM Classroom Practices. *CBE-Life Sciences Education*, *12*(4), 618–627. http://doi.org/10.1187/cbe.13-08-0154

Smith, M. K., Vinson, E. L., Smith, J. A., Lewin, J. D., & Stetzer, M. R. (2014). A Campus-Wide Study of STEM Courses: New Perspectives on Teaching Practices and Perceptions. *CBE Life Sciences Education*, *13*(4), 624–635. http://doi.org/10.1187/cbe.14-06-0108

Sunal, D. W., Sunal, C. S., Whitaker, K. W., Freeman, L. M., Odell, M., Hodges, J., … Johnston, R. A. (2001). Teaching Science in Higher Education : Faculty Professional Development and Barriers to Change. *School Science and Mathematics*, 101(5), 246–257.

APPENDIX A. COPUS CODES AND TEMPLATE

Observation codes

1. Students are 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 on fixing AV problems, instructor otherwise occupied, etc.)
O Other – explain in comments

2. Instructor is 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

3. Student Engagement (optional)

L Small fraction (10-20%) obviously engaged.
M Substantial fractions both clearly engaged and clearly not engaged.
H Large fraction of students (80+%) clearly engaged in class activity or listening to instructor.

Student engagement alternatives:

(1) Just mark when engagement is obviously high or obviously low.

(2) Count "N" students near you (~10) and assess how many appear engaged at every 2 minute interval. Enter value for all engaged instead of L/M/H. NOTE what your value of N was.

Suggestions regarding codes and comments:

- Clarify code choices with comments.
- Consider indicating your confidence regarding coding, especially when you aren't sure about choice of codes.

HOW TO USE OBSERVATION MATRIX: Put a check under all codes that happen anytime in each 2 minute time period (check multiple codes where appropriate). If no codes fit, choose "O" (other) and explain in comments. Put in comments when you feel something extra should be noted or explained.

52

Date:________________ **Class:** ________ **Instructor:** ____________________________**No. students** _______ **Arranged how?** ____________________________________

1. **L**-Listening; **Ind**-Individual thinking; **CG**-Clicker Q discussion; **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). OK to check multiple columns.

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																													
	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	
20 - 22																													
22																													
24																													
26																													
28 - 30																													

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

1. **L**-Listening; **Ind**-Individual thinking; **CG**-Clicker Q discussion; **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). OK to check multiple columns.

page 2

	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	
30 - 32																													
32																													
34																													
36																													
38 - 40																													
	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	
40 - 42																													
42																													
44																													
46																													
48 - 50																													

Further comments:

If you would like to have a protocol sheet that extends beyond 50 minutes, please check the following website: www.cwsei.ubc.ca/resources/COPUS.htm or contact the corresponding author (michelle.k.smith@maine.edu) for a modifiable spreadsheet.

APPENDIX B. ATTITUDES/BELIEFS QUESTIONS THAT COMPOSE INTENT SCORE

Intentions

I ***intend*** to engage in student-faculty interaction at some time during the next month."

1	2	3	4	5	6	7
Strongly **Disagree**	**Disagree**	*Slightly* **Disagree**	*Neither*	*Slightly* **Agree**	**Agree**	*Strongly* **Agree**

I ***plan*** to engage in student-faculty interaction for the next month.

1	2	3	4	5	6	7
Strongly **Disagree**	**Disagree**	*Slightly* **Disagree**	*Neither*	*Slightly* **Agree**	**Agree**	*Strongly* **Agree**

How ***willing*** are you to engage in student-faculty interaction at some time during the next month?

UNWILLING	1	2	3	4	5	6	7	**WILLING**
	extremely	quite	slightly	neither	slightly	quite	extremely	

I ***want*** to engage in student-faculty interaction at some time during the next month.

1	2	3	4	5	6	7
Strongly **Disagree**	**Disagree**	*Slightly* **Disagree**	*Neither*	*Slightly* **Agree**	**Agree**	*Strongly* **Agree**