Scholarship of Teaching and Learning Grant Proposal:

Implementation of a Partially Flipped Classroom to Better Engage Engineering Students and Develop Higher-Order Cognitive Skills

Dr. Kimberly Warren

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Director of Student Learning and Assessment

Civil and Environmental Engineering
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October 20, 2017

ABSTRACT

This mixed methods, pre-test/post-test control group design study will pilot and evaluate a Partially Flipped Classroom (PFC) pedagogy in a required engineering course to 1) determine if the new pedagogy can increase student engagement in the classroom, 2) evaluate student gains and determine if students can achieve higher-order cognitive skills, 3) evaluate changes in student perceptions and self-efficacy, and 4) identify/overcome challenges associated with implementing a PFC to develop a simple, flexible model that can be adopted by other engineering/STEM classrooms. For the lectures that will be flipped, students in the treatment group will begin the learning process outside of class at their own pace by watching technology clips. Classroom time will then be utilized to participate in active learning strategies (cooperative, inquiry-based, and problem-based learning) intended to increase engagement, help the students achieve higher-order cognitive skills, make the classroom more inclusive, and provide students with a variety of learning styles. This study would provide an opportunity to evaluate methods of using classroom time more effectively, impacts on student learning on a deeper level, and the ability to impact self-efficacy. If successful, the proposed PFC model would be integrated into the other core civil engineering courses at UNC Charlotte as part of a larger research initiative that will help the CEE Department improve student retention and progression within the Department. The extensive evaluation plan includes both formative and summative assessment designed to accomplish the four project objectives while collecting both quantitative and qualitative data from control and treatment student groups.

Budget Request for SOTL Grant
Year 2018-2019

Joint Proposal? ____ Yes __X__ No

Title of Project: Implementation of a Partially Flipped Classroom to Better Engage Engineering Students and Develop Higher-Order Cognitive Skills

Duration of Project: January 2018 – June 15, 2019

Primary Investigator(s): Kimberly Warren

Email Address(es): kawarren@uncc.edu

UNC Charlotte SOTL Grants Previously Received (please names of project, PIs, and dates): None

Allocate operating budget to Department of: Civil and Environmental Engineering

		Year One
Account #	**Award**	**Jan 2018 through June 2018**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	$ 3850
911250	Graduate Student Salaries	
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	
915000	Student Temporary Wages	
915900	Non-student Temporary Wages	
920000	Honorarium (Individual(s) not with UNCC)	
921150	Participant Stipends	
925000	Travel - Domestic	
926000	Travel - Foreign	
928000	Communication and/or Printing	
930000	Supplies	
942000	Computing Equipment	
944000	Educational Equipment	
951000	Other Current Services	
	GRAND TOTAL	$ 3850

		Year Two
Account #	**Award**	**July 2018 through June 2019**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	
911250	Graduate Student Salaries	$3240 (fall 2018) $3240 (spring 2019)
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	
915000	Student Temporary Wages	
915900	Non-student Temporary Wages	
920000	Honorarium (Individual(s) not with UNCC)	
921150	Participant Stipends	$450
925000	Travel - Domestic	$2500
926000	Travel - Foreign	
928000	Communication and/or Printing	
930000	Supplies	
942000	Computing Equipment	
944000	Educational Equipment	
951000	Other Current Services	
	GRAND TOTAL	$9430

Attachments:

1. A budget narrative that explains how the funds requested will be used is located on the following page.

2. Has funding for the project been requested from other sources? **No**

BUDGET NARRATIVE

Award	Amount	Justification
Faculty Stipend	$3850	Dr. Kimberly Warren will receive a faculty stipend to develop the necessary assessment instruments and conduct the full evaluation plan during the course of this 18 month project. *These funds will not support the development of the technology clips or course content.*
Graduate Student Salaries (911250)	$6480	A graduate student from the Department of Educational Leadership will be hired during the fall 2018 and spring 2019 semesters to help with the collection and analysis of evaluation data during this study. This student will also be responsible for conducting the pre-post focus groups each semester. The graduate student will be supervised by Dr. Kimberly Warren. It is estimated that the student will work 15 hours/week over 18 weeks each semester at $12/hour = $3240/semester * 2 semesters = $6480.
Participant Stipends (921150)	$450	This study will provide incentive $15 gift cards to Starbucks for students who participate in the pre-and-post focus group interviews. This is a standard amount of compensation to thank participants for their time in participating in the interviews. We anticipate 15 students (3 focus groups with 5 students each) will participate from each group and each student will be interviewed twice during the semester (15 students/semester * 2 semesters * $15 for both interviews = $450).
Travel – Domestic (925000)	$2500	Domestic travel has been requested to cover the expenses associated with the dissemination (publication and presentation) of a conference paper at the American Society of Engineering Education (ASEE) Annual Conference that Dr. Kimberly Warren will attend in June 2019. Expenses include registration (estimated $900), hotel and meals (estimated $950), and transportation (estimated $650).

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October 19, 2017

Scholarship of Teaching and Learning (SoTL) Grants Committee
Center for Teaching and Learning
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001

RE: Letter of Support for Dr. Kimberly Warren (Civil and Environmental Engineering)

Dear SoTL Grant Selection Committee:

Please accept this letter of support for the Scholarship of Teaching and Learning (SoTL) grant proposal entitled, "Implementation of a Partially Flipped Classroom to Better Engage Engineering Students and Develop Higher-Order Cognitive Skills", authored by Dr. Kimberly Warren in the Civil and Environmental Engineering (CEE) Department. This project will involve the implementation and evaluation of a partially flipped classroom in her geotechnical engineering course (CEGR 3278). In talking with her about her ideas, it is clear that Dr. Warren has reviewed the literature and is excited to execute and evaluate a well-planned, partially flipped classroom that is uniquely designed to increase teaching effectiveness and challenge our students in her classroom.

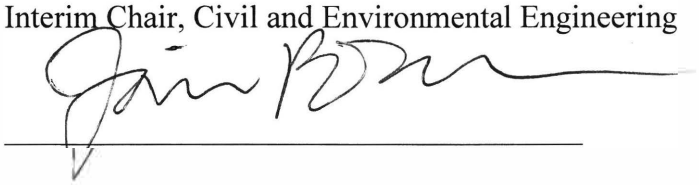
Our courses are growing in size and we have high demands to prepare our students for the Fundamentals of Engineering Exam taken in their senior year. This course is one of the core subjects on the civil engineering portion of this exam. If successful, this project has the potential to improve learning in the classroom and provide a solution to important challenges we are currently facing in our civil engineering classrooms: increased class sizes with decreasing student motivation and engagement. It is important that we find a teaching model that utilizes classroom time as effectively as possible given these conditions. I am hoping that the proposed model will positively impact student learning in her classroom, but also serve as a model for all of our core civil engineering courses.

Dr. Warren was previously funded by the National Science Foundation to create active learning tools in her geotechnical engineering classroom as part of a Laboratory and Course Improvement initiative, and has utilized these tools successfully in her class. This study had an extensive evaluation plan that included a strong collaboration with an assessment expert in the

Educational Leadership Department on campus. Her experience in developing active learning strategies and her knowledge of evaluation processes prepares her well for a SoTL grant. If funded, her ability to evaluate this research study will provide our Department and our College with some excellent techniques and lessons learned for implementation throughout our program. I have every confidence that she will execute her controlled study with excellence.

Dr. Warren was named Director of Student Learning and Accreditation in 2016 for the CEE Department, subsequently expressing an interest in developing a strong educational research program in Civil Engineering. Teaching excellence is her passion and our department continues to search for excellent teaching strategies and models that will be effective in the classroom and can be adapted in multiple courses. Our faculty have a long standing tradition of undergraduate teaching excellence that is supported by the department at all levels in our program. I strongly encourage this committee to support her and the proposed grant. Thank you (in advance) for your consideration.

Jim Bowen, Ph.D.
Interim Chair, Civil and Environmental Engineering



PROJECT NARRATIVE

(2493 words – excluding references)

A. Specific Aims

Overall Purpose

To handle the complex challenges associated with engineering and other STEM fields, engineering educators must ensure that students possess higher-order cognitive skills including the ability to critically analyze, conceptualize, and synthesize knowledge. The pace and presentation-style format of a traditional lecture makes it difficult for students to keep students engaged/motivated and achieve higher levels of learning in the classroom. Studies suggest that active, cooperative, inquiry-based, and problem-based learning strategies better support the development of higher-order cognitive skills, but effective use of these strategies takes time in the classroom, which is difficult to give up in engineering courses taught in a traditional lecture format due to the amount of content that needs to be covered.

Flipped classrooms have gained traction in recent years because this pedagogy enables the student to *begin the learning process outside of class at their own pace*, and subsequently, use the *in-class time to participate in active learning strategies that increase engagement* between faculty and student as well as student-student. The author proposes the implementation and assessment of a Partially Flipped Classroom (PFC) model a mixed methods pre-test/post-test control group design. For the treatment group, the instructor will utilize blended learning techniques from a typical flipped classroom in select lectures, but make specific adjustments to commonly cited course flipping issues to customize and optimize the student learning experience. *The overall purpose of this study is to pilot and evaluate a PFC instructional model in a required civil engineering course to determine what impacts this pedagogy has on student engagement, perceptions, learning, and gains.*

Research Objectives

1. Determine if a PFC instructional model can increase student engagement/motivation in the classroom;
2. Measure differences in student performance and determine whether this pedagogy will enable student to achieve higher-order cognitive skills;
3. Evaluate changes in student perceptions and self-efficacy during the course of the study; and
4. Identify and overcome challenges associated with implementing a PFC to develop a simple, flexible model that other faculty can implement into their engineering/STEM classrooms.

Research Questions

The following research questions will be addressed at the conclusion of this study:

1. Does the PFC instructional model enable students to reach higher-order cognitive skills (apply, analyze, and evaluate) and what activities facilitate these improvements?
2. Does the PFC instructional model improve student performance/scores for the flipped lectures? Does it also positively impact scores for the material that is not flipped for the treatment group?
3. What components/activities within the PFC instructional model do students find most engaging/effective and also struggle with the most?
4. Do student perceptions of the PFC instructional model change with time?
5. Does this pedagogy positively affect student self-efficacy?
6. What challenges are associated with the implementation of a PFC in an engineering classroom and what are the best practices learned from this study for implementation into other courses?

Research Rationale

With increasing classroom sizes and the competing power of personal technology in the classroom, it has become difficult to maintain consistent student engagement using the current lecture delivery format. Engineering courses are forced to deliver content in high volume. Using standard lecture-delivery format, the pace of our core engineering classes makes it difficult for students to achieve even the lowest levels of Bloom's Taxonomy during class (remember and understand). At the same time, students want instructors to slow down and provide more in-class, real world examples. To remedy these challenges and enable students to develop higher-order cognitive skills, a significant course re-design is necessary, and the author proposes the use of a PFC pedagogy to solve these challenges.

Anticipated Impact

It is hypothesized that the proposed PFC model will enable students to better achieve and move from the lower levels of Bloom's Taxonomy (remember and understand) to higher-order cognitive skills (the ability to apply, analyze, and evaluate) inside the classroom. Additionally, this model will provide students with an engaging classroom environment and create a more diverse learning environment. This study would provide an opportunity to fundamentally evaluate the ability to impact student learning on a deeper level and change their own perceptions of learning. If successful, the proposed PFC model would be integrated into the other core civil engineering courses at UNC Charlotte as part of a larger research initiative that will help the CEE Department improve student retention and progression within the Department. The author hopes that this model will be especially effective for select core civil engineering courses that have high DFW rates (Statics and Solid Mechanics). Lessons learned from this study can easily be extrapolated to any classroom at any level.

B. Literature Review

Bloom and Krathwohl's Taxonomy[1,2] measure a student's level of understanding based on the following six cognitive levels: (1) remember, (2) understand, (3) apply, (4) analyze, (5) evaluate, and (6) create. The American Society for Civil Engineers (ASCE) adopted Bloom's taxonomy to define levels of achievement associated with the body of knowledge necessary for entry into civil engineering professional practice[3]. Additionally, the engineering accrediting body (ABET) currently requires the evaluation of student outcomes that rely on the higher levels of Bloom's taxonomy[4]. Students receiving a conventional lecture delivery are unable to achieve higher levels of learning in the classroom due to pace of instruction and lack of time to provide adequate student engagement.

Research studies suggest that student retention in STEM fields requires modifying the classroom environment to better access varying learning styles[5]. The typical teaching approach utilizes abstract, verbal, passive, and sequential characteristics of the common learning styles, preventing students from reaching their full potential[6]. Felder and Brent[6] conducted a study that sampled over 2500 college students and professors around the world. They concluded that students and faculty are overwhelmingly visual learners even though material is more often delivered verbally. Additionally, students tend to comprehend more using their sensory, active, and global learning skills, but the delivery of the material does not reflect these strengths.

The National Academy of Engineering proposes a dramatic and fundamental transformation of engineering education to better prepare engineering students for the future as part of the Engineer of 2020 Project[7]. Much of the literature focuses on what the instructor is doing to do to deliver content rather than focusing on how best to get a student to interact with the content and/or take responsibility for their own learning[8]. Studies suggested that the inquiry-

based approach is an effective pedagogy that helps develop critical thinking, problem solving strategies, self-regulated learning, and collaborative learning in teams[9,10,11].

A flipped classroom is defined as "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom"[13]. At the conclusion of a study involving the review of 24 flipped classrooms by Bishop and Verleger[13], they encouraged future research to include performance measures and controlled study designs. Flipped classrooms have gained popularity in recent years, and methods have been well established in the literature[12,14,13,15]. Flipped classroom models make effective use of time, technology, and accommodate various learning styles[16,17,18], help students become self-directed learners[16,19], foster collaborative learning and personalized learning[17,20], increase classroom engagement and student-faculty interaction[20,21,19,18], and have been shown to improve student performance[22,17,16,23,24,25]. While flipped classrooms have been successfully incorporated into various STEM classrooms, the author is unaware of any studies that have attempted a flipped model in a geotechnical engineering course.

C. Methods

A list of action items that will be completed as part of this study are provided with the Timeline. This study will investigate the impacts of a Partially Flipped Classroom (PFC) model in a required, junior level civil engineering course (CEGR 3278: Geotechnical Engineering). Students are expected to learn the fundamentals of soil mechanics, which is heavily tested on their Fundamentals of Engineering Exam (engineers must pass as a first phase to their licensing process). The control and treatment groups will be taught during the fall 2018 and spring 2019 semesters, respectively. Importantly, the spring-summer 2018 semester will be utilized to

develop the technology clips for the out of classroom component, create the active learning strategies that will utilized to enhance the select flipped lectures, and develop that assessment instruments/grading rubrics to ensure that the goals of this study can be met. The course notes, the amount of material covered, the learning objectives/expectations, and the evaluation instruments will be identical for both groups. The author teaches this course and there are 40-60 students in this course each semester.

Control Group Activities

In general, the instructor will teach the control group using standard lecture format with supplemental examples and active learning tools as time permits.

- Course notes will completed during class and students will process/archive content during the lecture *at the normal pace of the instructor*. Due to the content volume and course pace, students are challenged to achieve the lowest levels of Bloom's Taxonomy during class (remember and understand).
- Students will post questions on the Canvas forum and submit their 'muddiest point' weekly.
- They will take a brief multiple choice quiz at the end of each class to assess their immediate understanding of the material, complete homework to develop a deeper understanding of the material, and complete 5 tests during the semester.

Treatment Group

The instructor will teach the treatment group using the PFC instructional model. The instructor will select lectures that are ideal candidates to be re-structured and flipped while the remaining topics will continue to be taught normally. For flipped content, the instructor will create 'slide-based' technology clips with attached annotations/audio that students will watch prior to class. The technology clips will align with the in-class activities, and all course

initiatives will support the course objectives. Slide-based clips will enable the instructor to modify content without having to re-record.

For all flipped lectures:

- Treatment group students complete their course notes while watching the technology clips outside of class. The content of the notes will be the same for both groups with slight modifications in format for the treatment group to keep the technology clips brief. These students will be able to process and archive the material *at their own pace* and take a brief multiple choice quiz at the end of the technology clip to ensure participation.
- It is hypothesized that this strategy will enable students to access/develop higher-order cognitive skills (remember, understand, apply, analyze, and evaluate) prior to class, further developing those skills in class from the active learning, inquiry-based, and problem-based learning activities.
- Students will post questions on Canvas prior to class and also submit their 'muddiest point' weekly.
- Posted questions will be utilized to create a 'content brief' at the beginning of each class (short review of the most important concepts and questions). This will help transition students from the technology clips to the active learning exercises in class. Inquiry-based and problem-based activities will be designed to engage students and promote higher-order cognitive skills in a supportive environment where both the instructor and their peers are there to help.
- They will take a brief multiple choice quiz at the end of each class to assess their immediate understanding of the material, complete homework to develop a deeper understanding of the material, and complete 5 tests during the semester.

D. Evaluation

This study will utilize a mixed methods, pre-test/post-test control group design. The skills, perceptions, and gains developed by student participants in a control group will be compared to the same data collected from the treatment group. It is assumed that the overall intellect of the students is equivalent across student samples, which is a fair assumption since enrollment numbers and demographic information doesn't change significantly from year to year.

Evaluation Plan

	Research Objective	Assessment Method
2 2	Improved Student Performance Higher-Order Cognitive Skills	• **Pre-Multiple Choice Quiz Questions (formative):** establish baseline knowledge • **Post-Multiple Choice Quiz Questions (formative):** parallel in content and difficulty, included in all tests/exam • **Muddiest Points (formative):** open-ended content feedback collected weekly • **Test Questions (formative/summative):** rubrics will be designed to assess student comprehension and level of cognitive learning; test questions will be compared to parallel final exam questions.
1 3	Increased Student Engagement/Motivation Changes in Student Perceptions and Self Efficacy	• **Pre-Post Scaled Student Surveys (formative):** questions that evaluate demographics (pre-only), self-perceived learning style, preferred teaching methods, preferred study/preparation methods, level of preparation for class, clarity of instruction, perceived gains, level of engagement, self-efficacy, time management, alignment of classroom activities with technology clips (treatment), use of technology (treatment) • **Pre-Post Focus Groups (formative):** focus groups will be recorded and transcribed to assess self-perceived learning style, preferred teaching methods, preferred study/preparation methods, level of preparation for class, clarity of instruction, perceived gains, level of engagement, self-efficacy, time management, alignment of classroom activities with technology clips (treatment), use of technology (treatment) • **Use of Course Website (formative):** analysis of usage data to evaluate student use of technology, frequency of posts/views. • **Attendance (formative):** records kept
4	Implementation Challenges	• **Instructor Journal (formative):** log experiences/observations regarding the implementation of the PFC model for treatment group • **Post-Student Survey (formative):** same questions • **Pre-Post Focus Groups (formative):** same questions

E. Knowledge Dissemination

Project results will be communicated to the UNC Charlotte community via participation in the UNC Charlotte SOTL Showcase and/or other CTL opportunities. Research results will be presented and published at the annual American Society of Engineering Education (ASEE) conference held in June of each year. Additionally, the author expects to publish in *Active Learning in Higher Education* (1.258 Impact Factor) or a similar journal, depending upon the results of the study.

F. Human Subjects

This study will involve collection and use of human subject data. If funded, the author will seek approval of all methods and instruments outlined in this proposal by the Institutional Review Board (IRB).

G. Extramural Funding

None.

H. Timeline

Task No.	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	June 2018	July 2018	Aug 2018	Sept 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	June 2019
1	X	X																
2	X	X	X															
3		X	X	X														
4		X	X	X	X													
5		X	X															
6			X	X														
7			X	X	X	X	X											
8								X	X	X	X	X						
9													X	X	X	X	X	
10													X	X	X			
11															X	X	X	X

Action Items:

1. Review current learning objectives to ensure they are specific and measureable for both participant groups and re-structure (chunk) the course content that will be flipped so it can be effectively conveyed in a technology clip.
2. Finalize pre-post student surveys and focus group questions.
3. Modify student test questions and create detailed rubrics that can evaluate cognitive levels of learning within the evaluation instruments.
4. Create detailed active learning activities for all PFC lectures.
5. Create, pilot, and evaluate a sample technology clip during the spring 2018 semester.
6. Based on the pilot, adjust evaluation instruments and/or technology as needed.
7. Create the technology clips.
8. Teach the control group and process/analyze data.
9. Teach the treatment group and process/analyze data.
10. Internal Dissemination (SOTL Showcase at UNC Charlotte).
11. External Dissemination (ASEE Conference 2019 and journal publication).

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