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Engaging Civil Engineering Students in Their Sophomore Year with a "Capstone-Like" Experience: The Anatomy of Springer 1

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ENGAGING CIVIL ENGINEERING STUDENTS IN THEIR SOPHOMORE YEAR WITH A "CAPSTONE-LIKE" EXPERIENCE: THE ANATOMY OF SPRINGER 1

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ABSTRACT

In their efforts to reinvent the civil engineering curriculum at Clemson University through the National Science Foundation grant program entitled Revolutionizing Engineering Departments (RED), Clemson University's Civil Engineering (CE) department has established the Arch Initiative. The Arch Initiative is Clemson's version of the RED program, and just like the first row of springer blocks that begin the formation of an arch, Clemson's CE department is developing a new course sequence (Springer 1 and 2) that aims to serve as the first level of the transformed CE curriculum. Springers are semester-long courses that emulate a capstone-like experience at the sophomore level by exposing students to real-world problems early on that will challenge them to develop new knowledge and skills. They will build on these skills during their junior and senior years through project-based learning and real-world applications. Faculty delivered a pilot course of Springer 1 in the spring semester of 2019, which introduced students to three subdisciplines of civil engineering: transportation, water resources, and construction management. The purpose of this thesis is to describe the development of the Springer 1 course and provide an evaluation of the course from a student learning gains standpoint based on surveys of the students who took the course. Two surveys were used in the assessment. The first Student Assessment of Learning Gains (SALG) survey was administered at the end of the course. The second survey was given in November 2020 after most of the Springer 1 students completed their junior year.

DEDICATION

This thesis is dedicated to my Father. Thanks for supporting me and teaching me everything I need to become the man I am today.

ACKNOWLEDGMENTS

I would like to thank my friends and family for who have helped me on my path to completing my goals. Without them I would not be where I am today. Thanks to Alena, who has always made sure to feed me even when I get so busy that I forget to eat. Thanks to my committee members who have dedicated time and effort to ensure the success of this thesis.

I would like to acknowledge my fellow Geomatics TA's who have worked alongside me through a relentless amount of grading over the years. Finally, I would like to thank Dr. Wayne Sarasua who is living proof that civil engineers have zero excuse for being boring. Dr. Sarasua has been my professor, advisor, boss, and a friend. Thanks for calling me in the morning to wake me up and get to work. Without you, I would not have completed graduate school. Go Tigers!

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CHAPTER ONE

INTRODUCTION

Civil engineering (CE) programs that are ABET-accredited are required to have a "curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints" [1]. Clemson's CE capstone course is a culmination of knowledge and skills learned and built on from previous CE courses where a student demonstrates their skills and tools through a semester-long project. For many students, the capstone project may be the first project that students undertake that emulates a real-world application in which they get to practice a civil engineer's job through an authentic design experience. Clemson's CE Capstone course was designed to equip students with the skills and knowledge they need to succeed after graduating and joining the workforce. Through a grant from the National Science Foundation's Revolutionizing Engineering Departments (RED) program, the Clemson University CE department is designing courses that will better engage students throughout the curriculum to improve their educational experience [2]. Clemson's NSF RED program is called the Arch Initiative. As part of the Arch Initiative, the Clemson CE department is also piloting a capstone-like experience into the curriculum at the sophomore level [3]. Similar to how "springer" blocks are the foundations of an arch, the Springer course sequence serves as a foundation for the new transformed CE curriculum illustrated in Figure 1.

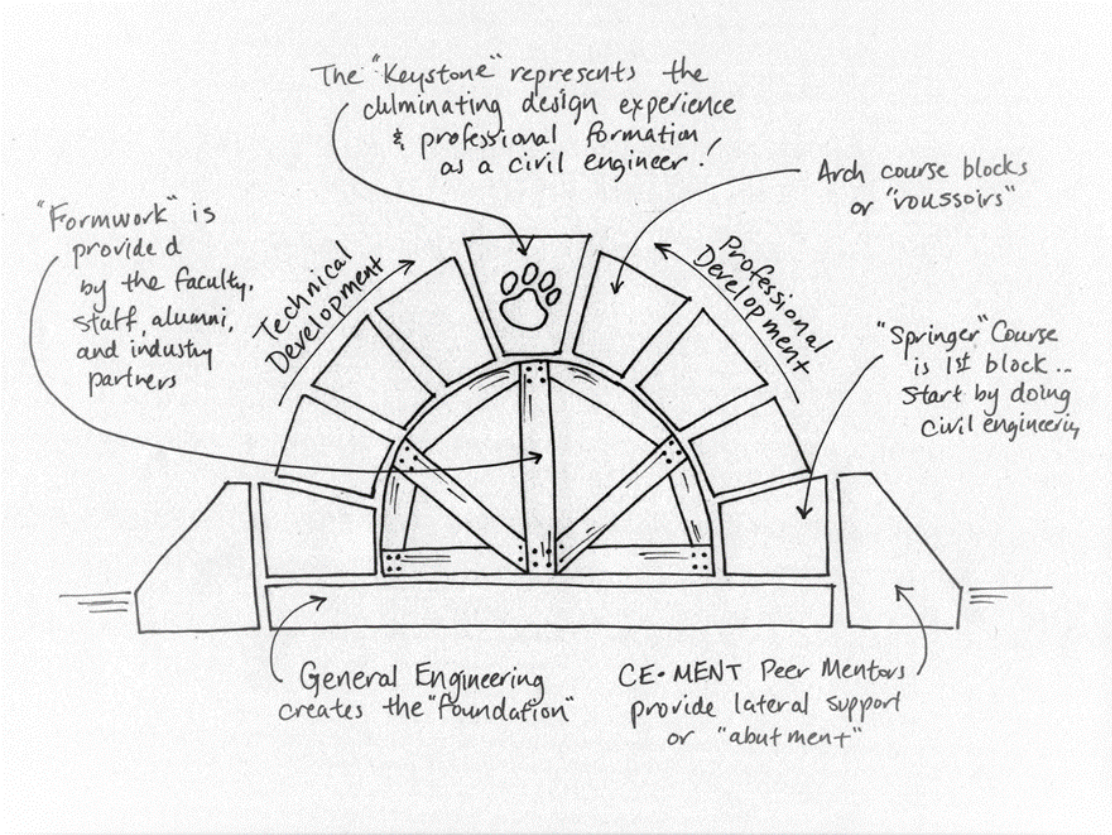


Figure 1: Arch Initiative Framework Sketch

The Springer course sequence aims to provide students with the "big picture" of civil engineering through real-world projects that will develop their teamwork and communication skills and provide a forum for professional interaction with stakeholders and industry professionals. The main expectation is that the Springer courses will better engage students at the beginning of their study to understand the significance of later courses and relate the material to professional work. A pilot course of Springer 1 offered in the Spring of 2019 introduced students to three subdisciplines: transportation, water resources, and construction management. A Springer 2 course that included most of the Springer 1 students was offered in the fall of 2020 and covered the remaining

subdisciplines and incorporating technical writing competencies. The purpose of this thesis is to describe and evaluate the Springer 1 course in all aspects, including the design, course content, teaching methods, assessment of students, Student Assessment of Learning Gains (SALG) survey, faculty resources, and challenges. Also included is an overview of the Springer 2 course and a description of a scaled-up Springer 1 course offered in Fall 2020.

Clemson NSF RED Program Arch Initiative

Clemson's NSF RED program Arch Initiative has the goal of transforming the CE curriculum to respond to the evolving challenges of highly interconnected and interdependent infrastructure systems and meet the societal needs of this century [4]. The Arch Initiative has three tactics.

- Tactic one is the transformation of the curriculum such that it invocates creativity and innovation to address the challenges previously mentioned.
- Tactic two will transform the department and its culture to promote an environment that encourages teamwork, inclusion, and the overall ability to collectively attain an intended result.
- Finally, tactic three focuses on growing and increasing college-level impact by using tactics such as discomfort zones and complexity leadership theory (CLT) to promote a vision that will be shared between CE departments at the national level.

Some detail on the tactics are shown in the figure below.

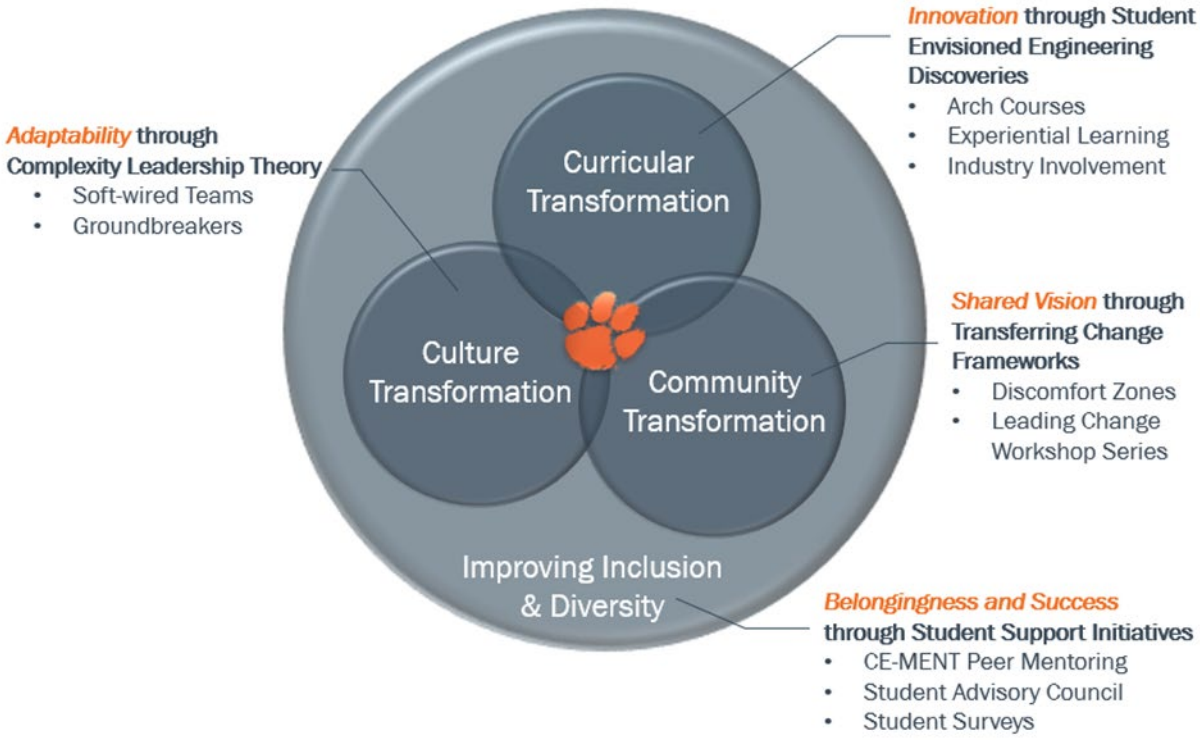


Figure 2: Arch Initiative Tactics

Clemson's Arch initiative intends to create an environment that will encourage interdependency and interactions between students and faculty so innovation can thrive. This will be made possible by creating a curriculum that acts as a scaffold that weaves coursework vertically and horizontally with a focus on meaningful problem statements that are socially relevant and practical [5]. Students face new challenges in this transformed curriculum, with the Springer 1 course being a foundation of the curriculum transformation and their first exposure to CE project-based learning problems.

Background

Traditionally, students attend class and learn in a lecture-based or teacher-centered environment in which they take notes in class and complete assignments at home. Some students do well in these courses and do not have a problem with this learning approach. However, some students struggle to grasp concepts. For the latter, few options exist. Feedback and guidance on approaching problems generally require locating the teaching assistant or professor for some one-on-one time where their questions can be addressed. Upon closer inspection of these students in a lecture-centered approach, one could discern the reasons why they struggle to grasp concepts. A passive learning approach, such as the conventional lecture-centered method, stifles students' ability to engage in active learning and discovery [6]. A student's understanding of the subject can be improved through an approach that both interacts and engages them.

Educators have experimented with various teaching methods to find more effective ways to learn and teach. When looking at methods such as flipped-classroom project-based learning (PBL), and cooperative learning, one notices the shift to student centered-learning from the traditional lecture-based or teacher-centered learning [7],[8],[9]. This shift is vital in advancing learning and will decisively increase the desired effect of supplementing students' learning growth and self-efficacy. Researchers have reported that project-based learning has the benefit of supporting experiential learning, fostering innovation, and closing the gaps between theory and practice [10],[11],[12]. Project-based learning is one of the essential aspects of Springer 1 highlighted in Clemson's Arch Initiative.

The nature of the Springer courses is a team-taught environment involving multiple faculty members of the civil engineering department and a faculty member from the communication department, thus simultaneously exposing students to multiple technical aspects of civil engineering and professional skill development. For this student-centered approach to be effective for learning, student motivation must be nurtured through key assignments and the proper channeling of course material development efforts. Through proper motivation and guidance, self-efficacy will increase, and students will have an improved belief in their ability to succeed, ultimately enhancing achievement [7]. Springer emphasizes project-based learning through its outlined objectives and learning assignments.

Thesis Objectives

This thesis's mains goals are to present information on all aspects of Springer 1 and add to the available knowledge-base for the incorporation of project-based learning at the early stages of a civil engineering curriculum. The overarching objectives of this thesis are:

- Convey the design of a Springer course
- Research the effectiveness of incorporating a capstone-like experience at the sophomore level
- Assess student learning outcomes from a Springer 1pilot course through the use of the SALG survey
- Identify challenges of permanently incorporating Springer 1 into the curriculum

- Assess the attitudes and development of students who took the original pilot course using a follow-up survey
- Make recommendations for future Springer courses based on an analysis of the survey data

CHAPTER TWO

SPRINGER COURSE FORMAT AND PILOT COURSE LOGISTICS

Course Objectives

Springer courses may vary in content from semester to semester based on the project selected and the subdisciplines involved, so the course objectives will not be identical. However, each Springer shares the same purpose of providing a "big picture" of civil engineering. In the two-credit Springer 1 course, students receive instruction in water resources, transportation, construction management, and content in oral communication. The plan for Springer 1 is to have students learn necessary background information in these subdisciplines so that they can later work in groups to develop conceptual and preliminary designs for a site development project. With this plan in mind, the faculty teaching team developed learning objectives and an outline for the course. The learning objectives are:

- Identify and describe civil engineering professionals' roles that focus on construction management, hydrology, and site/transportation disciplines of civil engineering.
- Produce conceptual civil engineering design plans, construction schedules, and cost estimates that meet specified requirements.
- Demonstrate basic levels of competency with civil engineering tools that can help students to be successful in future classes, including:
    - using CAD to create civil engineering drawings required for this course

    - using data analysis software for statistical and other engineering calculations
- Demonstrate basic levels of competency in professional skills that can help students to be successful in future classes, including:
    - applying creative problem-solving skills
    - developing an acceptable project stakeholder assessment
    - producing an acceptable set of project requirements
- Demonstrate a basic level of competency with the development and delivery of informative speeches and team presentations.
- Conduct an audience analysis.
- Explain the purpose, format, and roles of participants of a design charrette.
- Demonstrate an ability to work effectively in teams.

These objectives were carefully designed by associated faculty to maximize the learning gains of students throughout the semester. Each subdiscipline in Springer 1 conveys necessary technical knowledge that students need to complete and attain a real-world understanding of their mini-projects.

Course Format

The classroom that students enter to learn these subdisciplines and concepts plays a role in the environment that helps shape their learning. Documents that students will need, such as course work, subdiscipline resources, and the syllabus, are found in Canvas, the course management software used at Clemson. Springer is unique in its formatting as it is scheduled as a two-hour credit hour course that consists of two two-hour

laboratories, but the laboratory time varies depending on concepts learned that day. The lab time may be shorter if the material covered is predominantly lecture-based, running as little as 50 minutes. Labs may take the full two-hour slot if the material is predominantly project-based learning or if it is a day allocated for unique events such as the design charrette. The course schedule is shown in Table 1 below.

Table 1: Pilot Springer 1 Schedule of Course Material

Week #	Dates	Tuesday	Thursday
1	1/10	No class	Intro, history of CE
2	1/15-1/17	Comm	Intro talk
3	1/22-1/24	Water resources	Mini-Project
4	1/28-1/31	Transpo	Mini-Project
5	2/5-2/7	Constr	Mini-Project
6	2/12-2/14	Comm	Presentations
7	2/19-2/21	Team building	Project site visit
8	2/26-2/28	Project requirements	Sketch Design
9	3/5-3/7	Creative problem solv	Sketch/Charrette plan
10	3/12-3/14	Comm	Conceptual design
11	3/19-3/21	Spring Break	Spring Break
12	3/25-3/28	Conceptual design	Conceptual design
13	4/2-4/4	Charrette preparation	Design Charrette
14	4/9-4/11	Charrette debrief	Final Design
15	4/16-4/18	Final Design	Group presentations

Comm
Transpo (Coord)
Constr
Water resources
All

In the first week of Springer, students learn the history of the civil engineering profession and subdisciplines. They are exposed to a societal context and are given a brief introduction of the final project they will complete later in the semester. A portion of the first class is allocated to the introduction of communication competencies that will be covered during the semester. Fundamentals of public speaking concepts, informative speeches, project definition, group presentations, and technical and professional skills in each subdiscipline skills are laid out in the course objectives and are the focus of the next

six weeks of the course. The final six weeks of the course are related to designing the final project and involve a design charrette with stakeholder involvement and feedback. The classroom is a lab equipped with computers, projection equipment, and workspace available to promote collaborative work for more tangible assignments.

Teaching Methodology

Every teaching aspect of Springer 1 emphasizes the relevance of course material and assignments throughout the semester. A combination of teaching methods are used in Springer, such as traditional lectures and a flipped-classroom approach, but the primary teaching method is project-based learning. Project-based learning is an active learning approach that allows students to retain information learned for a longer duration and gives them valuable practical experience in a safe classroom environment [13]. Project-based learning is more engaging for students and is an effective method for a curriculum to allow students to demonstrate accumulated knowledge in a practical application [14],[15],[16]. Other findings researchers observed is that this pedagogical method is attractive to underrepresented and female students, which can lead to an environment that helps support a more inclusive student body [17],[18],[19].

Pilot Springer 1

Students were invited to the pilot Springer 1 course through various means such as email, advisor recommendations, and announcements in class. An incentive for taking the Springer course sequence was to replace one of the six technical elective requirements in the current CE curriculum. Twelve students enrolled initially but one had

to drop due to a scheduling conflict. Eleven students ultimately completed the course and are pictured at the project site with one of the faculty and the two teaching assistants for the course.

Figure 3: Spring 2019 Springer 1 Students and TAs along with one faculty

The grade point ratio (GPR) of these students range from 1.48 to 3.64 out of 4.0 with a mean of 2.97 and median of 3.19. By comparison, the mean GPR of similar sophomore level students enrolled in Clemson's civil engineering department is 3.2. The range of GPR in this small pool of students was deemed adequate to provide a reasonable assessment of potential learning gains from the course. Faculty randomly assigned students to groups to ensure coverage of prior course experience and student strengths in CAD, practical experience, and presentation delivery. Faculty members have decided that future group assignments will use a more sophisticated team formation algorithm such as CATME or ITP Metrics [20],[21]. Identification of students' strengths and weaknesses

through feedback and assessment will help determine their functions and roles in their teams and may lead to improved self-efficacy.

Initial Assignment and Communication Competencies

Students' first assignments in Springer 1 are assigned reading about civil engineering and watching videos about landmark projects such as the Golden Gate Bridge and the Hoover Dam. These materials expose students to the array of possibilities for what a civil engineer could do in their profession and pique their interest in learning more about the subject and what they may want to pursue. The next assignment involves the preparation and delivery of a short introductory speech about themselves to the class. This speech serves as an icebreaker and is recorded to capture the students' baseline in communication competencies. Factors such as sporadic movement, verbal fluidity, and overall presentation are assessed by the communication faculty member and are documented to convey feedback with comments for the student to work and improve on.

Next, students are tasked with preparing an informative speech in which they must choose a famous civil engineering project to research so they may once again present in front of the class while being recorded. This presentation typically has an overall improvement because students had to review their mannerisms and weak points from their previous video and observations made by the communication professor. The next set of communication-related tasks involved group exercises in conjunction with civil engineering subdisciplines. Students received a lecture on audience analysis and exercises to improve public speaking competencies. Group communication exercises are developed to prepare students for the design charrette where they must demonstrate their

progress by effectively communicating with stakeholders to assess various aspects of the final project. Public speaking practice and in-class exercises culminated into a final group presentation on the project. Again, the final presentation was recorded to allow for comparison with future presentation performance.

Transportation and Water Resources

A faculty member from the transportation subdiscipline of civil engineering lectured students in the history of transportation-related projects, which introduced them to real-world applications of transportation engineering. Each lecture was designed to build competencies in the subdisciplines and give information leading up to the first transportation mini-project. The transportation mini-project included necessary road design calculations and constructing an AutoCAD drawing of a roadway centerline based on the calculations. They were also given a topographical map where they must draw profile views along various sections. The last portion of the mini-project consisted of having students recreate a hardcopy design of a parking lot in AutoCAD. This exercise gives students insight into parking lot design through dimension analysis and layout and provides necessary practice to better prepare for their final project.

The water resources portion of Springer follows a similar plan of execution as the transportation portion. Students began their water resources learning by attending lectures on hydraulics and environmental engineering. After lectures, they were given a mini-project that consisted of downloading necessary rainfall data for the last 50 years from their hometown. They must plot their data, calculate the average and standard deviation for the wettest day, and produce a histogram of rainfall depth. Once they completed their

calculations, they compared the 10-year return period with a value of NOAA's 10-year return period.

Construction Management

Springer's construction management aspect was a teamwork-oriented portion that built on the communication between teammates and focused on increasing skills in scheduling, responsibility assignment, problem identification, and creative problem-solving. Some of the construction management assignments included a mini-project that consisted of a work breakdown structure. Students were tasked with scheduling a construction project where they identified the proper sequence of tasks to be achieved for the project to be completed efficiently. An in-class exercise had all groups write milestone events of the projects and placing those sticky notes on the board in front of the class. Each group was also assigned a segment of the project where they identified required tasks and respective sub-tasks. Finally, each group's segment of the project schedule was compiled into a master format and refined before submittal.

The construction management faculty member had students create responsibility assignment matrices (RAM) in which roles were assigned to group members such as the person responsible for the completion of the assignment, a member to check on that person to make sure it was completed, and a professor to sign off that they assisted the group. RAM was one of the more important assignments that students received since it directly helped team members hold themselves and each other accountable. This stage of the semester is when students really began to dive into group projects and presentations. After students individually created initial sketch designs, they created a group conceptual

design that combined selected aspects of each group member's sketch design. These conceptual designs were presented to the stakeholders at the design charrette.

Final Project and Design Charrette

The competency level demonstrated in Springer 1 is mainly at the conceptual or basic level, so the processes or level of detail of the designs must remain high. The final Springer project is a culmination of all practice exercises, mini-projects, and presentation knowledge acquired throughout the semester in the form of a hands-on, real-world experience assignment. In the first pilot, four-person groups completed the redesign of a parking lot located adjacent to campus at the Holy Trinity Episcopal Church shown in figure 4.

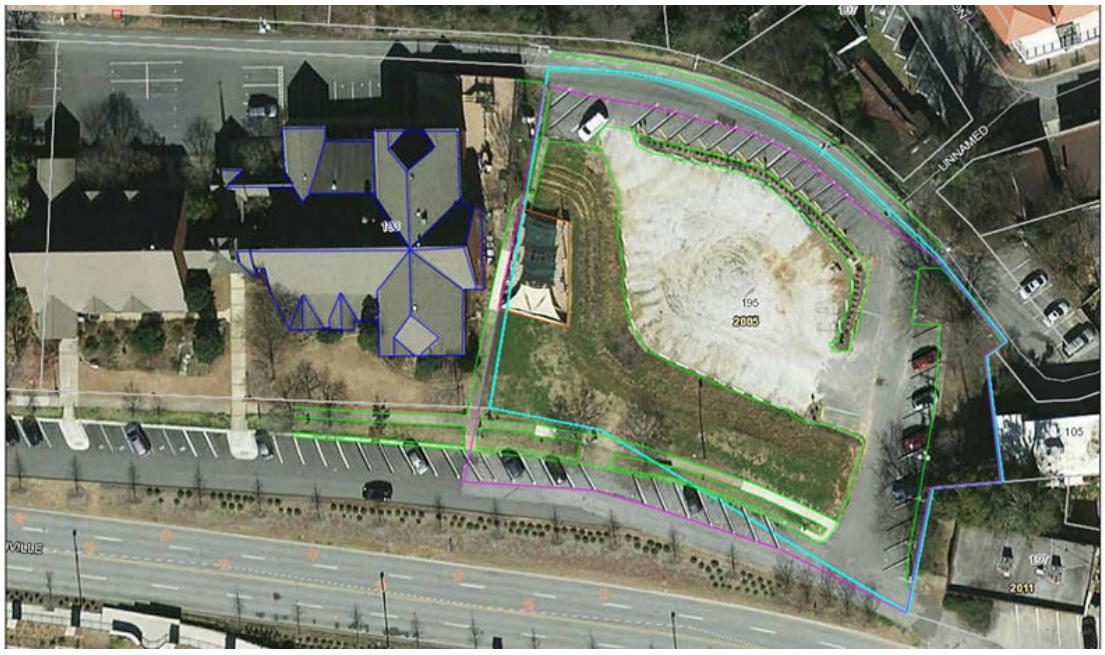


Figure 4: Pilot Final Project Site: Holy Trinity Church Parking Lot Redesign

Students began by identifying project requirements in a class discussion using techniques they learned from the course's construction management lectures. Individual rough design sketches were generated by students and were considered sketch alternatives. Each group discussed their members' alternatives and chose portions of each design that they accepted so they could draft a final sketch. Next, each group created a stormwater management plan and construction management plan that corresponded to their final sketch. Students received initial feedback from faculty members in preparation for the design charrette.

The incorporation of a design charrette in engineering classes has been shown to improve student engagement and provide a holistic design experience [22] [23] [24]. The Springer 1 design charrette took place during week twelve of the semester. Students identified key stakeholders before the faculty invited them for the charrette. One common format for civil engineering senior design capstone courses is for industry participants to listen to students' final presentations but have little to no involvement in helping students earlier [25]. All stakeholders who were invited accepted the invitation, and the stakeholders consisted of the city of Clemson staff members (assistant engineer and city planner), a campus planner well versed in football parking, residents who live near the site, and members of the Holy Trinity Episcopal Church. Two students were chosen by their peers to provide stakeholders with an overview of the project that included a discussion of the site, problem identification, challenges, and discussion of the charrette rules and process. Figure 5 below shows students interacting with stakeholders during the charrette.

Figure 5: Student Interaction with Stakeholders

On the day of the charrette, stakeholders were seated at specific tables, and student groups rotated to each table. For each stakeholder group meeting, individual group members were assigned a role. One group member was responsible for recording information, ideas, and comments from the stakeholders. Another member was assigned the role of a facilitator who presented their group's conceptual design and led discussion, and the remaining members acted as the support team. The charrette was broken down into ten-minute rounds with two-minute breaks in between each round.

The discussions between stakeholders and students included brainstorming ideas with stakeholders, questions, and answers. After time was called for round one, the two-minute break begins where team members helped their recorder assimilate ideas. After the two-minute break, groups were sent to the next table for round 2. Students changed roles in round 2 such that the team member with no assigned role became the new

recorder. The previous round's recorder became the facilitator that presented their group design and solicited ideas and comments from the new stakeholder group. This process was repeated for subsequent rounds until every group touched base with each stakeholder and every student had a chance to be both a facilitator and a recorder.

In the weeks following the charrette, students used the stakeholder feedback to complete their final design and produce a final report that included the stormwater and construction management plans. Students gave group presentations of their final project and submitted their final report during the last week of class. Figure 6 (a) and 6 (b) shows one group's conceptual and final design plans respectively.

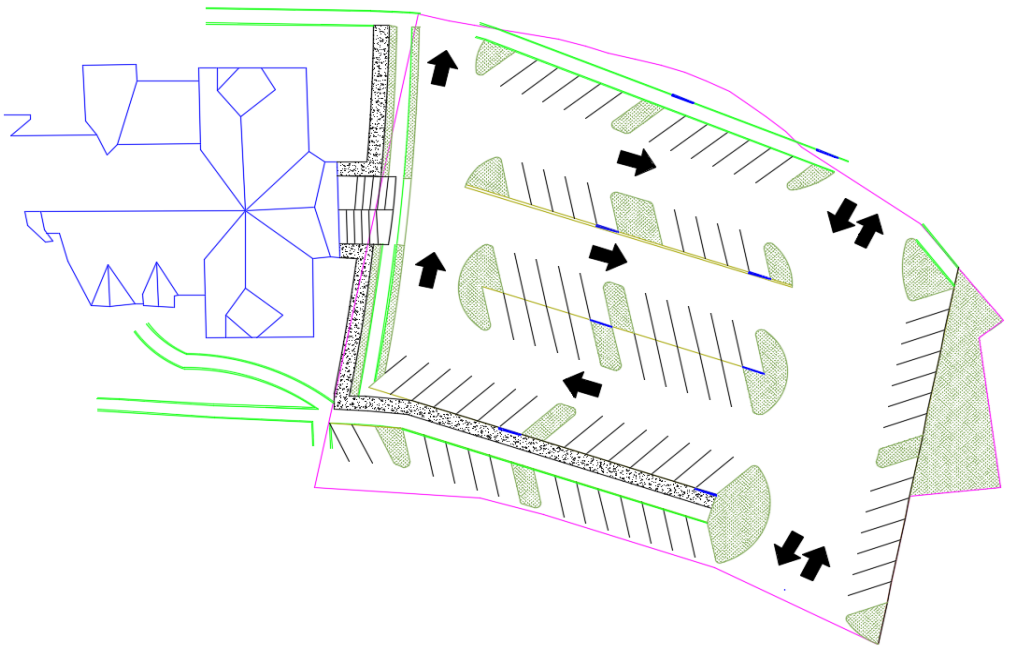


Figure 6 (a), Conceptual Design From One of the Groups

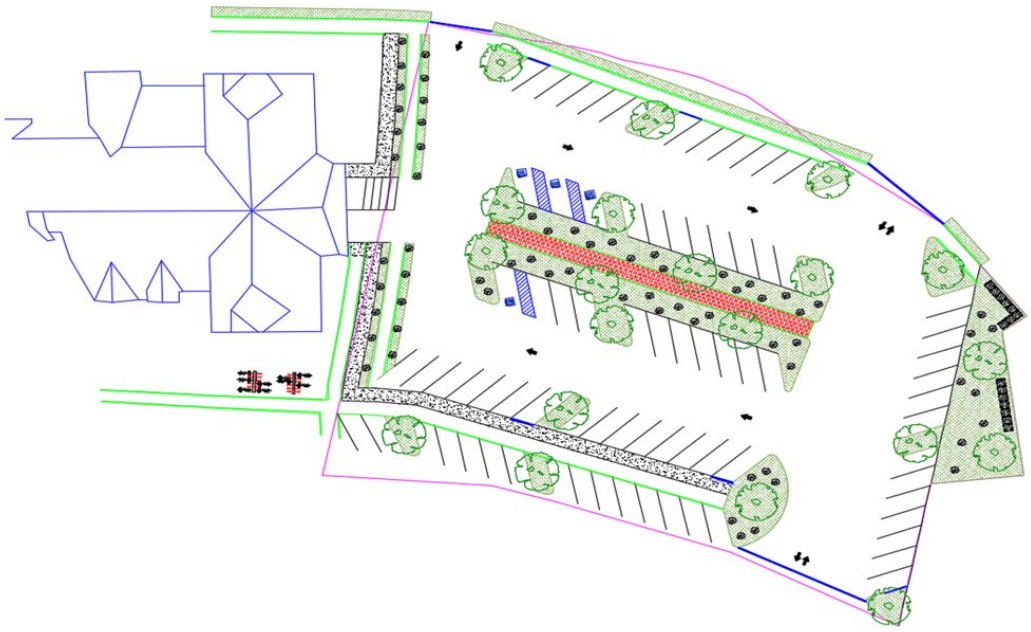


Figure 6 (b): Corresponding Final Design

CHAPTER THREE

DATA ANALYSIS AND RESULTS

Springer 1 Student Assessment and Course Evaluation

With a new PBL centered course such as Springer, the challenge becomes evaluating students and evaluating the course itself from multiple perspectives. Grades for the pilot Springer course were calculated based on a grading rubric designed by the faculty members. The final project totals 40% with a breakdown of: sketch plan 10%, conceptual design/design charrette 10%, final design 10%, and group presentation 10%. The final grade distribution of the pilot Springer course included 7 A's, 3 B's, and one student failed to submit a mini-project which resulted in a C. The average grade for the class equated to a 3.54 GPR which is almost half a letter grade higher than their overall GPRs prior to taking the course. The grading rubric was based on the following breakdown. It is estimated that approximately 50% of the course evaluation is based on oral communication (comm) aspects.

- Short speeches—5% comm
- Mini projects 10% each (30% total with up to 5% comm)
- Informative speech 10% comm
- Final project 30% (10-15% is comm)
- Group presentation 10% comm
- Final Exam 10% (5% is comm)
- Other assignments, attendance, participation 5% (mostly comm)

One of the ideas behind Springer 1 is to bring the communication requirement into the civil engineering curriculum so that students receive communication credit hours while also relating it to the profession and developing necessary professional skills.

Student Assessment of Learning Gains Survey

A Student Assessment of Learning Gains (SALG) survey was developed based on the learning objectives and was administered to the students in the final week of class. The survey consisted of open-ended questions and categorical questions ranging from 1 to 5, with 1 being no gain or no help and 5 being great gains or great help. None of the questions were required, but all 11 students completed the survey. The format for the SALG survey is shown in Table 2.1.

Table 2.1: Student Assessment of Learning Gains Format

	Number of Questions:	
Question Grouping	Categorical	Long Answer
Understanding of course content	6	2
Increases in your skills	17	1
Class impact on your attitudes	7	1
Integration of your learning	4	1
The class overall	3	5
Class activities	8	2
Assignments, graded activities/tests	9	1
Class Resources	3	1
The information you were given	3	1
Support for you as an individual learner	6	1

Table 2.2 gives a complete list of the categorical questions, along with the response means. The full format of the survey with individual student responses can be seen in Appendix A.

Table 2.2 Springer 1 SALG Questions and Response Means

#	Question	N	Mean
Your understanding of class content			
1	As a result of your work in this class, what GAINS DID YOU MAKE in your UNDERSTANDING of each of the following?		
1.1	The main concepts explored in this class	11	4.5
1.2	The relationships between the main concepts (e.g. how site design can influence storm water)	10	4.7
1.3	The following concepts that have been explored in this class		
1.3.1	The roles of civil engineering professionals who focus on construction management, water resources, and site/transportation disciplines of civil engineering	11	4.7
1.3.2	Conceptual civil engineering design plans, construction schedules and cost estimates that meet specified requirements	11	4.5
1.3.3	The purpose, format, and roles of participants of a design charrette	11	4.9
1.4	How ideas from this class relate to ideas encountered in other classes within this subject area	11	4.8
1.5	How ideas from this class relate to ideas encountered in classes outside of this subject area	11	4.5
1.6	How studying this subject area helps people address real world issues	11	5.0
Increases in your skills			
2	As a result of your work in this class, what GAINS DID YOU MAKE in the following SKILLS?		
2.1	Developing a work breakdown structure (WBS) for the design and construction portions of the course project	11	4.5
2.2	Developing a milestone schedule for the design and construction of the course project	11	4.3

2.3	Developing a detailed estimate for one work package from the course project	11	4.5
2.4	Using CAD to create civil engineering drawings required for this course	11	4.7
2.5	Using data analysis software for statistical and other engineering calculations	10	3.7
2.6	Applying creative problem-solving skills	11	4.5
2.7	Applying the Clarify, Ideate, Develop, Implement model to the course project and explaining how they converged to their final solutions	11	4.5
2.8	Developing an acceptable project stakeholder assessment	11	4.7
2.9	Identifying the primary stakeholders for the course project and analyzing how to manage each identified stakeholder using the Power/Influence matrix	11	4.6
2.10	Developing a list of primary course project requirements based on appropriate stakeholder interactions	11	4.6
2.11	Working effectively with others on a team	11	4.8
2.12	Developing a basic understanding of site design concepts	11	4.7
2.13	Developing a basic understanding of storm water management related to site design	11	4.6
2.14	Preparing and delivering informative oral presentations	11	4.5
2.15	Conducting an audience analysis	11	4.0
2.16	Preparing and delivering a project team presentation	11	4.7
2.17	Using presentation software (Powerpoint) to give effective presentations	11	4.2
Class impact on your attitudes			
3	As a result of your work in this class, what GAINS DID YOU MAKE in the following?		
3.1	Enthusiasm for the subject	11	4.6
3.2	Interest in discussing the subject area with friends or family	11	4.7

3.3	Interest in taking or planning to take additional classes in this subject	11	4.8
3.4	Confidence that you understand the material	11	4.3
3.5	Confidence that you can do this subject area	11	4.5
3.6	Your comfort level in working with complex ideas	11	4.6
3.7	Willingness to seek help from others (teacher, peers, TA) when working on academic problems	11	4.7
Integration of your learning			
4	As a result of your work in this class, what GAINS DID YOU MAKE in INTEGRATING the following?		
4.1	Connecting key class ideas with other knowledge	11	4.7
4.2	Applying what I learned in this class in other situations	11	4.5
4.3	Using systematic reasoning in my approach to problems	11	4.5
4.4	Using a critical approach to analyzing data and arguments in my daily life	11	4.2
The Class Overall			
5	HOW MUCH did the following aspects of the class HELP YOUR LEARNING?		
5.1	The instructional approach taken in this class	11	4.3
5.2	How the class topics, activities, reading and assignments fit together	11	4.2
5.3	The pace of the class	11	4.2
Class Activities			
6	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?		
6.1	Attending lectures	11	4.9
6.2	Participating in discussions during class	11	4.9
6.3	Listening to discussions during class	11	4.9

6.4	Participating in group work during class	11	4.9
6.5	Doing hands-on classroom activities	11	5.0
6.6	Specific Class Activities		
6.6.1	Team building activity	11	4.7
6.6.2	Creative problem solving activity	11	4.7
6.6.3	Design Charrette	11	5.0
	Assignments, graded activities and tests		
7	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?		
7.1	Graded assignments (overall) in this class	11	4.4
7.2	Specific assignments		
7.2.1	Introductory Speech (baseline)	11	3.3
7.2.2	Informative Speech	11	3.7
7.2.3	Construction Management mini-project	11	4.1
7.2.4	Transportation Systems mini-project	11	4.1
7.2.5	water resources mini-project	11	4.1
7.3	Final project	11	4.9
7.4	The way the grading system helped me understand what I needed to work on	11	3.6
7.5	The feedback on my work received after assignments	11	3.6
	Class Resources		
8	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?		
8.1	Online notes or presentations posted by instructor	11	4.6
8.2	Other online materials	10	4.7
8.3	Visual resources used in class (i.e. PowerPoint, demonstrations such as CAD, Excel, web resources)	11	4.5

	The information you were given		
9	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?		
9.1	Explanation of how the class activities, and assignments related to each other	11	4.5
9.2	Explanation given by instructor of how to learn or study the materials	11	3.7
9.3	Explanation of why the class focused on the topics presented	11	4.6
	Support for you as an individual learner		
10	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?		
10.1	Interacting with the instructors during class	11	4.7
10.2	Interacting with the instructors during office hours	10	4.2
10.3	Working with the teaching assistant during class	11	4.9
10.4	Working with the teaching assistant outside of class	11	4.8
10.5	Working with peers during class	11	4.9
10.6	Working with peers outside of class	11	4.8

Students were conscientious of completing the survey because almost all students gave input to every free response question. The categorical questions ranging from 1 to 5 yielded responses as follows: over 90% of responses average 4 or greater, nearly 75% over 4.5, and 3 questions received a perfect 5.

When looking at the categorical questions of the SALG survey, one can surmise the portions of Springer 1, which, in the opinion of the students, provided the greatest learning gains. Tables 2.3 and 2.4 below show the relevance of course material inside and out of the subject based on the high average response.

Table 2.3: Questions 1.4 and 1.5 of SALG Survey

1.4	How ideas from this class relate to ideas encountered in other classes within this subject area	11	4.8
1.5	How ideas from this class relate to ideas encountered in classes outside of this subject area	11	4.5

Table 2.4: Question 2.4 of SALG Survey

2.4	Using CAD to create civil engineering drawings required for this course	11	4.7

The table above shows that CAD competency is one of the more valued skills attained by the Springer 1 students.

Table 2.5: Question 2.5 of SALG Survey

2.5	Using data analysis software for statistical and other engineering calculations										
	student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
	3	5	2	2	5	3	5	5	9	5	2

Section 2 of the SALG received nearly all responses averaging 4 or higher. The lowest average received in section 2 is part 2.5 as seen in the above figure. This survey question relates to the water resources mini-project in which students must use Excel to tabulate and graph analytical rainfall data. This learning outcome averaged a score of 3.7, and may be attributed to multiple factors including: minimal assistance is given on the use of Excel, students receive significant training in Excel in general engineering, and this task is similar to tasks previously completed in other courses. Based on some of the highest averages from section 2, students noted the greatest learning gains in CAD software, assessment of project stakeholders, effectively working with others in a team, and preparing deliverables for projects, and team presentations.

Responses from the open-ended questions give insight into Springer 1 that are the most effective and aspects that can be improved moving forward. When prompted to comment on "skills they have gained as a result of Springer 1" in section 2.18, most of the responses focus on aspects that are directly linked to the course objectives. Some students mentioned their development of ideas in the brainstorming portion and linking their ideas with stakeholders and their teammates. One such student responded to the question with:

> "During this class I learned a lot about the deliverables that define a project and how to create them. I wish we had more discussion about how to create the project management documents for our specific project. My ability to work and communicate within a group improved greatly and I am more confident for future group projects. I learned to trust my group mates and have open discussions about the project."

This quote indicates that combining the CE discipline with the communication discipline is an effective means of developing intercommunication and teamwork skills among students. Other responses in section 2.18 show that students received gains in CAD skills that tie in content from ENGR 2100, the general engineering AutoCAD course, to applications of civil engineering. Students have an increase in enthusiasm and interest for the civil engineering based on responses shown in Table 2.6.

Table 2.6: Questions 3.1-3.3 of SALG Survey

3.1	Enthusiasm for the subject	11	4.6
3.2	Interest in discussing the subject area with friends or family	11	4.7
3.3	Interest in taking or planning to take additional classes in this subject	11	4.8

Looking at 5.4 in the SALG survey "please comment on how the INSTRUCTIONAL APPROACH to this class helped your learning", one can see that the faculty members are successful in improving interest in the subdisciplines and students obtain a genuine understanding of the topics through instruction. This question's responses demonstrate the effectiveness of using a faculty team-taught course because students mainly responded positively to having multiple professors to help focus their learning.

Table 2.7: Free Response Question 2.18 of the SALG

student 3	I think teamwork was a big part of the class throughout the semester. Although I certainly improved my teamwork skills, I could tell other peers did as well. Also, we used AutoCAD in more practical ways than in ENGR 2100 and I was able to improve my software skills.

Table 2.8: Free Response Question 3.8 of the SALG

student 2	Before taking this class, I just saw engineering as a bunch of equations and calculus that I was going to have to do. After taking this class, I am positive that I want to be involved in some aspect of Civil Engineering and I get excited to tell my family about my projects that I have done in Springer 1 because it is an actual design and a real life problem we were trying to fix instead of just a sheet of calculations. After designing this parking lot, it makes me excited to see what I can do after I graduate and learn more.

The tables above are student responses to questions 2.18 and 3.8 that show effectiveness of the Springer teaching methodology. The response to 2.18 demonstrates Springer's effectiveness in delivering CAD competencies as this student mentions the practical use of the software when compared to the AutoCAD learned in ENGR 2100,

which is a general engineering course required as part of the civil engineering curriculum. The response from question 3.8 indicates that Springer 1 reinforces a student's ambition and excitement for civil engineering and effectively encapsulates the desired capstone like experience. Some aspects of the course that were effective include having resources readily available to them, such as assignment information, course documents on Canvas, access to professors, and their recorded presentations.

To supplement the SALG survey, a teaching consultant from Clemson's Office of Teaching Effectiveness and Innovation (OTEI) observed Springer 1 and received feedback from students on three questions. The questions have a similar sentiment to those of the SALG and are shown in tables 3.1 and 3.2. Based on some of the student responses, such as those from Question 1, students find that having projects and exposure to real-world implementation of their learning helps them learn more.

Table 3.1: Question 1 of Supplemental OTEI Student Focus Group

Group Feedback	Compilation of comments from students:
Q1. What helps / supports your learning?	The group activities and student involvement; the discussions and team environment
	Projects > exams
	Real-world civil engineering problems are very insightful
	The design charette
	The essays and speeches
	The incorporation of water resources, construction management, transportation, and communication into the final projects
	Very helpful to have stakeholders/outsiders come to class for feedback; communication with the stakeholders
	The exposure to all of the sub-disciplines in civil engineering
	The size of the class allows for better relationships with the professors, and getting to know everyone to go through curriculum with them
	Its fun
	Having a TA who is always present and participating in projects

Table 3.2: Questions 2 and 3 of Supplemental OTEI Student Focus Group

Q2. What could be done to improve your learning?	Some mini-projects feel off-topic
	Lectures can be long, so we have less time for the group work in class and missed out on "lab time" we should have had
	Professor presence and availability during class – for scheduled time that professor is asked to be there to answer questions and clarify expectations
	Work piles up onto major test weeks
	Course workload doesn't feel like just 2 credits of work
	Coordination between professors, which would help with the workload expectations of all 4 and what they are assigning; and overall organization
Q3. What can you do to improve your learning	Ask more questions
	Practice my presentations
	Study more outside of class
	Work ahead on this course while other course loads are lighter
	Connect with others in the class on projects
	Not be afraid to try new things

Questions 2 and 3 of the OTEI supplemental survey have some notable responses that could be used to improve Springer 1 in future semesters. Based on question 2, students feel that their course load is a little cumbersome, and the lecture portions tended to run longer than anticipated. As this was the first offering of the course, the faculty have begun working to recalibrate the material and the mode to have a set 50-minute lecture and 2.5-hour lab in future offerings. Students identified that asking more questions, "trying new things," and working ahead of time would be helpful for their learning. Faculty have determined to seek Springer alumni to return to the class early in the semester to provide insight to peers.

Springer Post-Survey

A Springer post-survey was designed to track the progress of students who took Springer 1 in the Spring of 2019 during their sophomore year. Most of the Springer 1 students were seniors as of fall 2020 when the post-survey was given, and of the 11 students who participated in the pilot of Springer 1, 9 completed the post-survey. The idea behind the post-survey was to assess the effectiveness of the Springer course sequence in the CE curriculum and extract relevant information on how it impacted their learning in other CE courses while also comparing their learning outcomes to their peers who have not taken Springer.

The Springer post-survey was formatted similar to the online SALG tool and consists of free response, multiple-choice, and categorical questions rated 1-5 with 1 being strongly disagree, greatly decreased, or far less confident while 5 represents the opposite sentiments. The Springer post-survey format can be seen in table 4.1, and the

questions, responses, mean, and median for Springer post-survey questions can be seen in table 4.2. The full detailed post-survey with every student's response can be seen in Appendix B. Note that question 5 has been removed as it related to Springer 2, and is not related to the objectives of this thesis.

Table 4.1: Springer Post Survey Question Format

	Number of Questions:	
Question Grouping	Categorical	Long answer
Understanding of course content post Springer 1	4	0
Learning impact of Springer on future courses	8	6
Relevant student feedback for improving Springer	0	4

Table 4.2: Springer Post Survey Question Response Means and Medians

#	Question	N	Mean	Median
Understanding of course content post Springer 1				
1	As a sophomore starting out in civil engineering, Springer 1 gave me a better understanding of the different Civil Engineering subdisciplines and future courses that I could take.	9	4.44	5
2	Springer's Transportation projects provided an improved understanding of the different Civil Engineering subdisciplines and future courses I could take.	9	4.33	5
3	Springer's Water Resources projects provided an improved understanding of what to expect in future water resources courses (hydrology, fluids, etc.).	9	3.56	4
4	Springer's Construction Management provided an improved understanding of what to expect in future construction courses.	9	3.67	4
Learning Impact of Springer on future courses				
6	Did Springer 1 increase/decrease your identity as a Civil Engineer?	9	4.67	5
7	As a sophomore starting out in civil engineering, participating in Springer 1 improved my sense of belonging in the CE department.	9	4.78	5
8	After taking Springer 1, I felt (more or less) confident in my choice of major.	9		5
9	Overall, I believe that Springer 1 should be a required course.	9		
9.1	Why not?	3		
10	Do you believe Springer 1 should be a 2 or 3 credit hour course?	9		
11	I feel more confident with my communication skills as a result of taking Springer 1	9	4.11	
12	Do you feel like teamwork skills learned in Springer 1 have benefitted you in other courses			
12.1	Teamwork questions	9	4.63	
12.2	Creative problem solving	8	4.5	

12.3	Intercommunication between teammates	9	4.75	
12.4	Group presentations	9	4.63	
12.5	Time management skills	9	4.38	
13	What aspects of Springer 1 have you applied in other courses (Civil Engineering or otherwise)?			
14	Springer courses gave me a better idea of which civil engineering subdiscipline that I wanted to focus on.	8	4.25	4.5
15	The communication aspect of Springer 1 was an important part of that course	9	4.22	4
16	How has Springer influenced your participation in other Civil Engineering courses?	9		
17	How, if at all, has participating in Springer courses helped you in Junior or Senior level CE courses?	9		
18	Please comment on how your attitude of Civil engineering has changed going into your junior year due to springer	9		
19	Do you feel like you were more/less prepared for future courses than peer students who didnot participate in Springer courses?	9		
20	In your opinion, do you feel like your education in civil engineering was different from peers who did not participate in Springer courses? If so, how?	8		
Relevant student feedback for improving Springer				
21	Please comment on aspects of Springer 1 that you would want to ensure remain the same.	8		
22	Please comment on changes, if any, that you would want to make to Springer 1.	8		
23	What is the worst thing about Springer 1?	8		
24	What is the best thing about Springer 1?	8		

After looking at the individual responses, it was apparent that one student tended to deviate significantly from others' responses. Thus, a median value was included in the table for comparison against the average score to identify predominant responses. There is an overall positive response from students with all categorical questions for Springer 1, averaging 4 or greater. The first 4 questions of the post-survey ask students to reflect on their learning of the subdisciplines and rate how effective they were in improving their understanding either before or during a higher-level course of that subdiscipline.

Table 4.3: Question 1 of Springer Post Survey

#	Question	N	Mean	Median
Understanding of course content post Springer 1				
1	As a sophomore starting out in civil engineering, Springer 1 gave me a better understanding of the different Civil Engineering subdisciplines and future courses that I could take.	9	4.44	5

Based on Question 1 shown in the figure above that has an average of 4.44 and a mean of 5, one can see that Springer has helped students understand what future courses or path they may want to take.

Table 4.4: Questions 6 and 7 of the Springer Post Survey

Learning Impact of Springer on future courses				
6	Did Springer 1 increase/decrease your identity as a Civil Engineer?	9	4.67	5
7	As a sophomore starting out in civil engineering, participating in Springer 1 improved my sense of belonging in the CE department.	9	4.78	5

Responses for questions 6 and 7 shown in table 4.4 indicate that Springer 1 has effectively reinforced students' sense of identity and belonging to civil engineering. Some of the highest-rated scores in the survey show the positive impacts that Springer has on students, reinforcing their confidence and competencies in civil engineering. These values also indicate certain aspects of Springer 1 are retained moving forward through the curriculum. Question 13 and the graphical representation are shown table 4.5 and figure 7.

Table 4.5: Question 13 of the Student Post Survey

13	What aspects of Springer 1 have you applied in other courses (Civil Engineering or otherwise)?

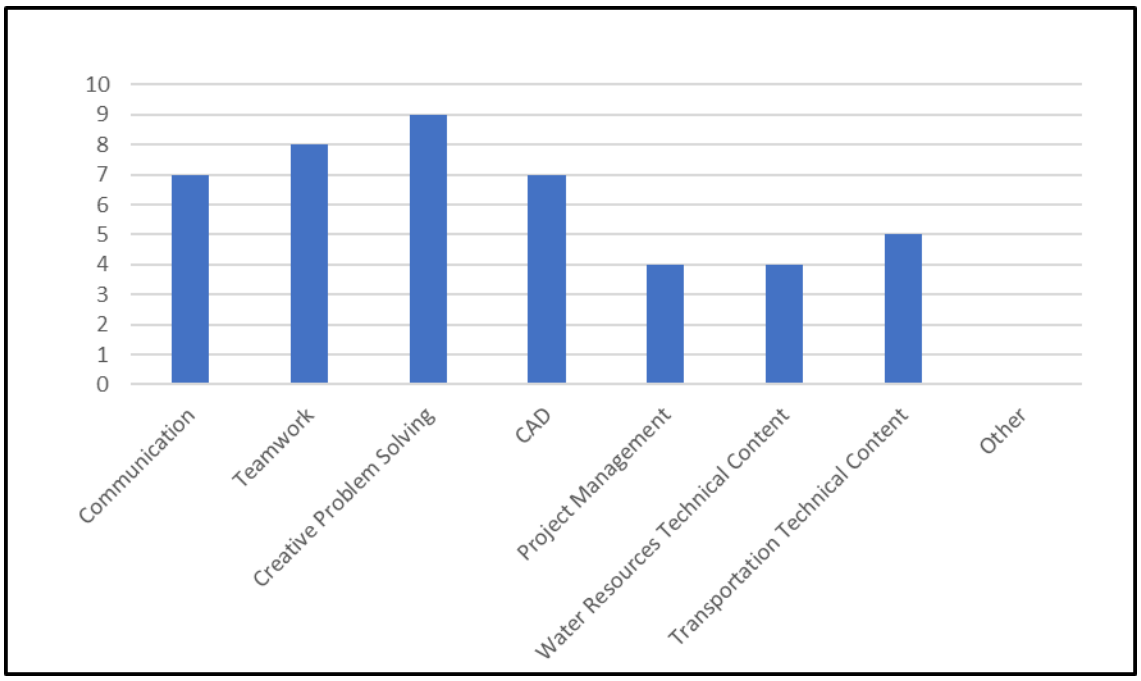


Figure 7: Question 13 Chart of Skills Students Have Selected

From this figure, one can see that most students have applied teamwork, CAD, communication, and creative problem-solving skills to other courses. This indicates that enrolling in Springer effectively grants students lingering valuable skills moving forward through the civil engineering curriculum.

Two-thirds of the students who took Springer 1 say that it should be a required course in the curriculum. Among the three responses that believe it should not be required, two of them indicate that the course curriculum would need structural improvements before full implementation. Given that this was a pilot course, that was the intent to test methods and make improvements. These responses fall in line with Arch

Initiative goals for a full-scale implementation of Springer 1 in the civil engineering curriculum. Seven of the nine students believe that Springer 1 should be a three-credit-hour course. One can ascertain that these responses derive from the accumulated time students spend working in and outside of class and the course load containing a final project, presentation, and exam.

The first 5 free-response questions of the Springer post-survey were designed to gauge attitudes towards Springer and collect valuable information in comparing education to those of their peers.

Table 4.6: Question 19 Springer Post Survey Free Response

Student 7:	More prepared. It was definitely helpful just to have some exposure and familiarity with subjects before getting into the super technical content.

Question 19 asks students if they feel "more/less prepared for future courses than peers who have not taken Springer," and one notable response can be seen in the table above. The response above shows that this student feels they have an increase in their familiarity with the subject and a better grasp of concepts. Most responses show that students do feel better prepared than their peers. However, a true assessment cannot be made to show that these Springer students are better prepared for future courses than their peers because these surveys do not contain a side-by-side comparison of course results from both groups.

Table 4.7: Question 22 Springer 1 Post Survey Free Response

Student 5:	I think there should be more organization and planning ahead. I also think it needs to be made clear how much time will be spent in class. For example, we were told we would have 1 hour one day, and 2 hours the other day but we ended up staying 2 hours both days and we were not planning on that.

When asked to comment on changes they would make to the course in question 22, students provide feedback that can be expected from a pilot. The table above shows a response from question 22 and based on this response, Springer 1 could improve in its organization and expectations. Responses from questions 17 and 18 show that students gain perspective in the subdisciplines that help them connect real-world projects to technical skills. Some students report that they received a baseline understanding of the subjects prior to entering future courses and that they could focus on the assignments and projects instead of fixating on the grade they receive. This statement indicates that Springer effectively invokes an engineer's technical and creative thinking mentality while teaching students how the pieces of the puzzle fit in the bigger picture. Almost all responses from question 20 show that Springer students feel that they are better prepared, more interested, and value their education in civil engineering than their peers who have not taken Springer, which reinforces the observations generated from question 19.

The final four free-response questions contain feedback on what students like and dislike the most about Springer 1 and aspects they would want to remain the same or change about the course. Most student responses indicate that they mainly want to ensure that Springer remains team-taught with multiple professors, keeps its stakeholder involvement, and stays oriented toward group projects. Students would make changes consisting of organizing the course structure while laying out more explicit expectations early on. Students feel that the "worst thing" about the pilot Springer course is the lack of expectations and unclear organization, which can be expected as a course is piloted for the first time – especially when four faculty are involved who have never worked

together in this capacity. Question 25 shows that their favorite aspects of the course are working in groups, the class atmosphere, non-traditional stress-free learning, and the engagement between the professors and students.

CHAPTER FOUR

DISCUSSION AND CONCLUSION

SALG and Post Survey Conclusions

Comparing the responses from both the SALG and the Springer post-survey, one can see what students find to be the most valuable aspects of Springer 1. The first is its orientation towards building team skills and competencies. These teamwork skills are among the highest-rated aspects of Springer 1 in both surveys and are retained in future classes. The next aspect is connecting class exercises to the bigger picture of civil engineering. Student responses in the SALG indicate that they have a baseline grasp of how the pieces (or subdisciplines of CE) fit together and understand why the projects are necessary to connect them. At the same time, the post-survey shows how they have a more robust baseline understanding of the subdisciplines than that of their peers who have not taken Springer going into higher-level classes. The final most valuable aspect that students find is stakeholder involvement, which received excellent reviews from both surveys and stakeholders.

Challenges and Opportunities

Students who took the Springer 1 pilot course did so voluntarily. The greatest challenge for permanent adoption and implementation of the Springer sequence as required courses in the Arch Initiative revised civil engineering curriculum is meeting enrollment demand. Clemson's civil engineering department currently has roughly 150 sophomore students who would need to take both of the Springer courses. The

independent design of the two sophomore courses allows flexibility because they can be taken in any order. The sentiment of the faculty involved in the pilot Springer 1 is that the number of students for a section can easily increase two-fold (~20 students). While the format of two 2-hour flexible length classes per week worked well for the pilot, the scheduling and faculty resources needed to teach 4 sections of Springer 1 per semester may be too ambitious. The faculty involved in Springer 1 agree that reorienting the class as (1) 50-minute lecture and one 2.5-hour lab per week is achievable. Considering a semester in which 80 students register for the course, the workload would involve two lecture sections of 40 students and four lab sections of 20 students. In-class exercises and computer usage are still possible in a lecture section with 40 students if students are required to bring notebook computers, and adequate TA support is provided to assist students.

Faculty resources are still a concern; however, Clemson plans to hire a full-time oral/written communication instructor to support instruction for both Springer classes as well as other undergraduate civil engineering classes. The current civil engineering curriculum requires that students take a communication and a technical writing class outside of the department. The Civil Engineering department plans to work with the university constituents to allow both oral and written communication to be integrated into Springer and other proposed civil engineering classes. Having a full-time in-house communication instructor is anticipated to improve the coordination among the instructors and provide consistency of instruction across the entire curriculum.

The involvement of faculty from different subdisciplines in the Springer series is resource intensive; however, the current format for the existing capstone course is taught in a similar fashion with one lead instructor and three consulting faculty. There is also TA support for capstone. In moving forward with the curriculum transformation, the Arch Courses are based on concepts of quality over quantity. Therefore, flexibility in workload assignment and additional weighting for project-based and team-taught courses is critical. Department and college administrators must find solutions to replace simple teaching load models based on course credit. Four faculty teaching a 2-credit Springer course amounts to 0.5 credits per faculty in a standard workload system, but if we value this pedagogical approach and the benefits received by students' new models must emerge providing more credit for these faculty.

Another challenge is identifying an adequate number of appropriately scoped projects each semester. One significant finding of the pilot class is that the course design allowed the entire section to work on the same project. Thus, having a single project each semester that is worked on by four different sections will still achieve desired results from a student perspective. Having adequate stakeholder involvement in the design charrette may be of even greater concern. Fortunately, in Clemson there is a significant pool of potential stakeholders that have already expressed interest in getting involved with future classes. A great opportunity exists to develop and strengthen our alumni involvement within the Arch Initiative. Further, the recent transition to online learning during the COVID-19 pandemic has opened new possibilities to involve stakeholders from outside the local area.

Second Pilot for Springer 1 During Fall, 2020

Some of the faculty concerns and challenges identified from the pilot Springer 1 course are being addressed or tested out in Fall 2020's iteration. One of the immediate changes planned for the Fall 2020 Springer was to scale up the offering to 40 students, including one 50-minute lecture section and 2 2.5 hour lab sections. While this format was used, the actual enrollment was only 24 students resulting in two lab sections of 12 students each. Another notable change was that the course had to be partially online due to COVID-19 pandemic institutional effects. For the first month of the fall semester, Clemson University's policy was to move all learning online. Students used Zoom to attend classes, and as the semester went on, learning was switched to a hybrid format where lectures were online and labs were in-person. If a student could not make it to class because of COVID-19 , they could attend online through Zoom.

The fall 2020 Springer 1 course followed a similar assignment structure as spring 2019's Springer 1 as it consists of mini-projects, team exercises, stakeholder involvement, and communication exercises. There may be some underlying effects of Covid-19 on student learning online that may be unidentified. However, classes retained the same values as the pilot course, and it is evident from the faculty-student interaction that students were still engaged in course content. Another significant change was that the charrettes for the two lab sections were moved entirely online. The charrette seemed to go well with the added benefit that stakeholders could be anywhere and still attend. After the design charrette, some stakeholders gave unsolicited positive feedback indicating that they found the online charrette to be a rewarding experience for both them

and students. The convenient format of an online charrette goes a long way to address the challenge of attracting stakeholders in the future. Because this thesis was completed prior to completion of the course, SALG survey data was not yet available however informal discussions with the students and faculty indicate that the course was a success.

Recommendations

Based on all feedback received from both surveys and observations made during the Fall 2020 Springer 1, Springer can improve some aspects further. Students feel that the organization and expectations of Springer could be refined. Based on the challenge of scaling course material that Springer 1 faces, one method would be to combine faculty ideas of course content scheduling early on. Identification of methods that have been proven to be successful should be prioritized. Faculty members bring in new ideas to iterations; however, implementing each new idea can become cumbersome to students' workload. Changing the Springer to three credit hours invites new challenges and can conflict with the course's scope because subdiscipline material would need to be increased to match the hours. At the end of the second offering, most faculty agree that Springer 1 could remain a two-credit hour course; however, class exercises and mini-projects should reflect a two-credit hour course. The elimination of smaller exercises or assignments that are expendable would be one course of action that can improve the overall challenge of scaling the course material. The communication component seemed better integrated from observations in the Fall 2020 because the faculty were more attuned to working together in the team-taught course. The SALG survey may indicate that the changes made this semester are more in-line with a 2 credit course.

The pilot Springer 1 course attempted to layout expectations and relevance of course material in each assignment, and the fall 2020 Springer 1 iteration improved the delivery of expectations, but this aspect has been identified as a problem for students and can be further improved. One method would be to communicate the expectations as assignments are posted and incorporate more detailed rubrics that explicitly define expectations. Students also identified the organization of the course as a problem but that is to be expected since it was a pilot course. This issue can be easily resolved with a clear detailed schedule, plan of action, and effective communication between faculty members. With time, the organization will become more refined, and any glitches in the team-taught course will be less apparent to students.

If there is a need to address a scale-up challenge by eliminating an aspect of the course—the design charrette and stakeholder involvement should remain at all costs. With all project-based courses comes scale-up issues that may seem insurmountable, and the benefits and values that students will receive often necessitates innovation and creativity from faculty. Overall based on student, faculty, and stakeholder feedback, the design charrette is an irreplaceable experience unique to Springer that fosters professionalism, communication, creativity, and challenges students to utilize resources presented to them in order to achieve the next level of learning early in the curriculum.

Final Conclusions

This thesis has provided an evaluation of Springer 1 and laid out all aspects of the Springer 1 course along with identifying challenges and opportunities for improvement. Based on key findings and survey responses, Springer 1 has improved when scaled up

and will continue to improve based on new student responses. Pilot Springer 1 students find that students are better prepared for teamwork and have improved in professionalism, communication, presentation, technical, and projects skills. Positive feedback from the pilot makes it clear that students are better engaged, more interested than their peers who have not taken the course and have a reinforced drive to face future infrastructure challenges after graduation. These observations draw the conclusion that Springer 1 has successfully accomplished many of its objectives and successfully mimics a capstone-like experience at the sophomore level. The incorporation of a PBL style Springer 1 as a foundation course in the redesigned civil engineering curriculum will successfully produce the desired results of better engaging students, improve self-efficacy, and properly challenge students in an environment that values quality over quantity. Springer courses are just the beginning of the redesigned curriculum. Additional changes will need to be made as complications are identified however, based on student feedback, Springer 1 should be a required course for civil engineering.

APPENDICES

Appendix A

Student Assessment of Learning Gains Survey

1	**As a result of your work in this class, what GAINS DID YOU MAKE in your UNDERSTANDING of each of the following?**									
1.1	The main concepts explored in this class									
	student 1 4	student 2 5	student 3 5	student 4 4	student 5 4	student 6 5	student 7 5	student 8 5	student 9 4	student 10 5	student 11 4
1.2	The relationships between the main concepts (e.g. how site design can influence storm water)									
	student 1 5	student 2 5	student 3 4	student 4 5	student 5 5	student 6 5	student 7 9	student 8 5	student 9 5	student 10 5	student 11 3
1.3	**The following concepts that have been explored in this class**									
1.3.1	The roles of civil engineering professionals who focus on construction management, hydrology, and site/transportation disciplines of civil engineering									
	student 1 5	student 2 5	student 3 4	student 4 4	student 5 5	student 6 5	student 7 5	student 8 5	student 9 5	student 10 5	student 11 4
1.3.2	Conceptual civil engineering design plans, construction schedules and cost estimates that meet specified requirements									
	student 1 5	student 2 5	student 3 4	student 4 4	student 5 5	student 6 5	student 7 5	student 8 5	student 9 3	student 10 5	student 11 4
1.3.3	The purpose, format, and roles of participants of a design charrette									
	student 1 5	student 2 5	student 3 5	student 4 5	student 5 5	student 6 5	student 7 5	student 8 5	student 9 5	student 10 5	student 11 4
1.4	How ideas from this class relate to ideas encountered in other classes within this subject area									
	student 1 5	student 2 5	student 3 5	student 4 4	student 5 5	student 6 5	student 7 5	student 8 5	student 9 5	student 10 5	student 11 4
1.5	How ideas from this class relate to ideas encountered in classes outside of this subject area									
	student 1 4	student 2 5	student 3 5	student 4 4	student 5 5	student 6 5	student 7 5	student 8 5	student 9 3	student 10 5	student 11 4
1.6	The relationships between the main concepts (e.g. how site design can influence storm water)									
	student 1 5	student 2 5	student 3 5	student 4 5	student 5 5	student 6 5	student 7 5	student 8 5	student 9 5	student 10 5	student 11 5

1.7	**Please comment on HOW YOUR UNDERSTANDING OF THE SUBJECT HAS CHANGED as a result of this class.**
student 1	The ability of the material learned in class to be applied to real world enhanced my knowledge of the subject.
student 2	Instead of just seeing equations and learning how to do problems designed for those equations, I learned how to work each equation into the real world application of designing a parking lot and when changes needed to be made to such equations. I also learned how to work around others' involvement and that I couldn't just create a design that fit my requirements but also the requirements of the stakeholders involved.
student 3	From participating in this class, I learned not only basic skills in hydro, transpo, and construction, but also about civil engineering as a whole.
student 4	Being able to just see how the subjects apply to the real world.
student 5	Springer was one of the first civ e courses I have taken. I now understand more what a civ e does.
student 6	I have always questioned how I would be using skills/ knowledge from my classes in a practical engineering setting so springer was an eye-opening experience and made other course more enjoyable to because I could see a little bit of how they play a role in the design/ project realm.
student 7	Understood how construction stormwater and design is taken from idea to finish product.

student 8	I learned about what Civil Engineers for their usual jobs and how to properly communicate engineering ideas to non-engineering people.
student 9	I have gained a better understanding of the cross-over of the different subjects
student 10	We got to see first hand how we have to communicate, and a lead a team to get a project done. Also, we used helpful tips from each lecture to influence the final design of our project.
student 11	I feel like a have a brief introduction into some the class I will encounter later and am much better at working in groups.

1.8

Please comment on how THE WAY THIS CLASS WAS TAUGHT helps you REMEMBER key ideas.	
student 1	By incorporating a project in the class using the material learned in class, I was able to remember the material better.
student 2	Working in groups helped me learn and remember what was taught in class. Having the professors give us an assignment and then constantly being there and helping us through the assignment helped me really understand what was being taught. Having projects instead of written exams was key to understanding what I was learning. Instead of just trying to memorize formulas for an exam, I would work a project and if it didn't work like I needed it to, I could go back and ask questions and understand what I did wrong.
student 3	I thought the idea of splitting each class into an hour of lecture and an hour of lab was helpful in helping us learn more about each topic. We were able to take in the information and then immediately apply it in a group setting.
student 4	Being exposed to the different areas per week along with assignments that relate to the subject taught helped me remember.
student 5	Sarasua is a good professor and makes sure you understand the material by applying it. I was confused by Kayes lectures, in that I had no initial education on what he taught, but the way he taught assumed we had past education on water resources. Sanders made really long presentations that were interactive, but the length made students inattentive
student 6	Being able to actually practice skills in a real world project definitely solidified the concepts in my mind and made me feel more confident in my abilities.
student 7	Hands on with real world problems helps.
student 8	The class was taught by lecturing us on a topic and then assigning us a mini-project to work on ourselves.
student 9	The way the material was briefly over-viewed at the beginning of the course and then was basically re-done during the main project helped me remember it better
student 10	Since everything was on a power point and we had access to that, it was easier to engage during the lecture and refer to the power point to refresh ourselves on the topic.
student 11	I liked how the class was focused on projects instead of exams and quizzes. The class was very hands on and allowed me to feel like I was applying what I learned.

2

As a result of your work in this class, what GAINS DID YOU MAKE in the following SKILLS?										
2.1 Developing a work breakdown structure (WBS) for the design and construction portions of the course project										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	4	4	5	4	5	5	4	5	4

2.2

Developing a milestone schedule for the design and construction of the course project										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	4	3	5	4	5	5	4	5	4

2.3

Developing a detailed estimate for one work package from the course project										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	3	5	4	5	5	4	5	5

2.4

Using CAD to create civil engineering drawings required for this course										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	5	5	4	5	5	5	5	4

2.5

Using data analysis software for statistical and other engineering calculations										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	2	2	5	3	5	5	9	5	2

2.6

Applying creative problem solving skills										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	4	5	5	5	5	3	5	5

2.7

Applying the Clarify, Ideate, Develop, Implement model to the course project and explaining how they converged to their final solutions										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	2	5	5	5	5	5	4	5	5

2.8

Developing an acceptable project stakeholder assessment										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	4	5	4

2.9

Identifying the primary stakeholders for the course project and analyzing how to manage each identified stakeholder using the Power/Influence matrix										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	3	5	5

2.10

Developing a list of primary course project requirements based on appropriate stakeholder interactions										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	4	4	5	5	5	5	4	5	5

2.11

Working effectively with others on a team										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	5	5	5	5	5	5	5	5

2.12

Developing a basic understanding of site design concepts										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	5	5	5	5	5	4	5	5

2.13

Developing a basic understanding of storm water management related to site design										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	4	4	5	5	5	5	5	5	5

2.14

Preparing and delivering informative oral presentations										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	5	5	5	5	5	2	5	4

2.15

Conducting an audience analysis										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	4	3	5	5	5	5	1	5	3

2.16

Preparing and delivering a project team presentation										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	5	5	4

2.17

Using presentation software (Powerpoint) to give effective presentations										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	4	4	5	5	5	5	3	5	2

2.18

Please comment on what SKILLS you have gained as a result of this class.	
student 1	Communication skills as well as civil engineering skills

student 2	I have gained skills in presenting speeches as well as powerpoints. I have learned that when doing these, simple is always best instead of flashy eye catchers. I have learned how to trust members of my team fully instead of trying to do every aspect of an assignment myself and with that team, I have learned how to learn from my teammates things that I am not an expert in, but they are.
student 3	I think teamwork was a big part of the class throughout the semester. Although I certainly improved my teamwork skills, I could tell other peers did as well. Also, we used AutoCAD in more practical ways than in ENGR 2100 and I was able to improve my software skills.
student 4	overall teamwork skills and communication as a whole. Also being able to again use AutoCad so that I would not forget it.
student 5	I now know how to better develop multiple ideas for a design, and how to present design that both meet requirements, and present designs to discover requirements (the design charrette)
student 6	I really liked the stakeholder involvement and having a chance to learn communication skills in a setting that is much more applicable to my future than a normal comm class.
student 7	Better communication and professionality.
student 8	I have learned how to properly work with others as a team on a large project.
student 9	I learned a lot about water management and construction management and transportation
student 10	I have gained a better understanding of team work, and communication. I did improve on giving a presentation and answering questions.
student 11	During this class I learned a lot about the deliverables that define a project and how to create them. I wish we had more discussion about how to create the project management documents for our specific project. My ability to work and communicate within a group improved greatly and I am more confident for future group projects. I learned to trust my group mates and have open discussions about the project.

3 **As a result of your work in this class, what GAINS DID YOU MAKE in the following?**

3.1 Enthusiasm for the subject

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	5	5	4	5	5	4	5	5

3.2 Interest in discussing the subject area with friends or family

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	4	5	5	5	5	5	5	5

3.3 Interest in taking or planning to take additional classes in this subject

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	5	5	5

3.4 Confidence that you understand the material

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	3	4	5	5	4	5	3

3.5 Confidence that you can do this subject area

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	4	4	5	5	4	5	5

3.6 Your comfort level in working with complex ideas

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	4	5	5	4	5	5

3.7 Willingness to seek help from others (teacher, peers, TA) when working on academic problems

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	3	5	5

3.8 **Please comment on how has this class CHANGED YOUR ATTITUDES toward this subject.**

student 1	Becoming closer to my classmates through this course will help increase my enthusiasm because I am not the only one embarking on the new curriculum.

student 2	Before taking this class, I just saw engineering as a bunch of equations and calculus that I was going to have to do. After taking this class, I am positive that I want to be involved in some aspect of Civil Engineering and I get excited to tell my family about my projects that I have done in Springer 1 because it is an actual design and a real life problem we were trying to fix instead of just a sheet of calculations. After designing this parking lot, it makes me excited to see what I can do after I graduate and learn more.
student 3	I have been given a broader knowledge of the discipline of Civil Engineering. This has helped me be more enthusiastic about taking future classes and my future career.
student 4	N/A
student 5	I have a better understanding of what I do and do not wish to engage in in the future
student 6	Getting a taste of several facets of civil engineering was fun and made me think more about what kind of career i would be interested in in the future.
student 7	Seems much more interesting now.
student 8	I am still excited to be a civil engineer.
student 9	This class increased my appreciation for the material
student 10	This subject made more eager to graduate and find a job because doing a project like this was fun and hearing input throughout was helpful.
student 11	This class made me more comfortable talking to my professors and exposed me to how a project is done outside of class. Working on a real site that we went and visited made me much more enthusiastic about the project and I enjoyed seeing how my groups design compared to the one that is actually being built.

4 **As a result of your work in this class, what GAINS DID YOU MAKE in INTEGRATING the following?**

4.1 Connecting key class ideas with other knowledge

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	5	5	4

4.2 Applying what I learned in this class in other situations

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	4	3	5	5	5	5	4	4	5

4.3 Using systematic reasoning in my approach to problems

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	4	3	5	5	5	5	5	4	5

4.4 Using a critical approach to analyzing data and arguments in my daily life

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	3	3	5	5	5	5	4	4	3

4.5 **What will you CARRY WITH YOU into other classes or other aspects of your life?**

student 1	Skills developed in this class
student 2	I will carry with me the cooperation and teamwork needed to do well in this class as well as the real life applications I have learned that I have already seen in my other courses.
student 3	Hopefully I will find ways to apply this to both future classes and internships before graduation.
student 4	teamwork and communication skills along with site designing
student 5	Communication,AutoCAD, and the general basis of construction management, transportation, and water resources for my future courses. Communication, AutoCAD, and a general understanding of civ e for my internship.
student 6	Understanding that the material we are learning throughout the curriculum has a purpose and will be useful in the future will help me be motivated to aim to excel in other courses.
student 7	Making connections to how i will use things in the real world.
student 8	I will continue to think critically about how to solve a problem.
student 9	I will carry the knowledge of water resources into my fluids course
student 10	What I will carry out into another class or life is not having an ego. You cannot have an ego in anything because it will cause a person to not listen to others.

student 11	From this class I will take some basic understanding on the concepts that can be applied in other classes and context for the coursework. I think this class will allow me to see more application for my future classes.

5 HOW MUCH did the following aspects of the class HELP YOUR LEARNING?

5.1 The instructional approach taken in this class

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	2	5	5	5	3	4	5

5.2 How the class topics, activities, reading and assignments fit together

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	4	3	4	5	5	2	5	5

5.3 The pace of the class

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	5	1	4	5	5	3	5	5

5.4

	Please comment on how the INSTRUCTIONAL APPROACH to this class helped your learning.
student 1	I like how different professors were brought in to teach about their unique field of study instead of 1 professor teaching about all of the material.
student 2	The instructors seemed more interested in making sure we knew what we were doing rather than just getting their topics covered and then forgetting about us. They saw our interest in the project and were willing to meet with us whenever we needed to explain things.
student 3	I liked having an hour of lecture and an hour of lab to practice what we just learned.
student 4	N/A
student 5	The instructural approach was to first introduce an idea on an unrelated topic to what the students would use the ideas on for the final project.
student 6	I liked having multiple professors because it helped even out the focus of the class rather than having a professor who is only an expert in one subject and doesn't focus on the other parts as much.
student 7	I think that students learn better by doing then a more theoretical approach.
student 8	The instructor taught us a topic, gave us a mini-project, and had us apply it into the big project.
student 9	It helped to work at our pace and then be able to ask the professors questions
student 10	The instructors always told us the why factor so we had a better understanding to what we were doing.
student 11	I liked having multiple professors teach their different aspects of the class. I also liked being graded on projects rather than quizzes/exams because it seems like a more fair way to judge understanding of the material.

5.5

	How has this class CHANGED THE WAYS YOU LEARN/STUDY?
student 1	Project-based learning is better than exam-based learning
student 2	I found out I learn best when I am directly involved with something instead of just reading about it or listening to how it is done. Now when I study, I copy down problems and every step it takes to solve. I also study with groups and we all discuss best ways to solve problems and why and it makes you think about why you would use certain equations.
student 3	I've studied with people from this class for other CE classes.
student 4	N/A
student 5	I now will try harder to apply what I learn in class to other aspects of my life to help let learn better
student 6	This course helps me see the relevance of the coursework I'm doing and motivates me to have a thorough understanding so that I can have valuable skills in the future.
student 7	Instead of just caring about grades care about what you can take away from it.
student 8	N/A
student 9	It helped me to want to study with other students
student 10	I have been more productive in group studying and leading the study groups.
student 11	This class did not really affect how I study as there were no exams to take.

5.6

What aspects of the class did you like the most?

student 1	I like how we incorporated a project and worked in teams to come up with a final design
student 2	I liked the teamwork and projects instead of exams. I also liked how involved the professors were. It made the whole class become friends and work on everything together which really helped.
student 3	I liked the class size. We had 11 people and 4 professors. I got to know each peer and each professor much easier than in a normal lecture setting.
student 4	N/A
student 5	The use of AutoCAD. I enjoy using AutoCAD.
student 6	Getting to play engineer in a real project.
student 7	The design charette.
student 8	I liked the Transportation Sections the best.
student 9	The real world project
student 10	the team work
student 11	I liked working on a real project.

5.7

	What aspects of the class did you like the least?
student 1	Some of the availability of the professors were not ideal
student 2	I didn't like the mini projects at the beginning of the course because they didn't seem to have any relation to the work we were doing for the project. Also, I understand the course was generally planned, but even the professors didn't know exactly what we were going to do, which made us rushed at the end to finish everything that ended up being required.
student 3	It's a brand new class, so understandably it was somewhat unorganized. Assignment and project expectations and requirements changed a few times.
student 4	N/A
student 5	Water resources
student 6	Assignments that weren't related to the project.
student 7	All of the communication portion was a waste of time. The communication we had between eachohter was already enough.
student 8	I liked the communication sections the least.
student 9	The way we basically did the topics twice instead of using them as we needed them in the project
student 10	The mini projects
student 11	I wish the class was more organized.

5.8

	Please comment on how the class can be improved
student 1	I think students should be exposed to the project earlier in the semester
student 2	It can be improved just by being more planned out which it should be if it's going to be our new curriculum.
student 3	Now that they have a curriculum for Springer I, they can use it rather than create it as we go.
student 4	N/A
student 5	The instructors should discuss more how they each plan to lecture and assignment assignments/projects so no that the students don't feel overwhelmed between the different professors for one class.
student 6	I would have liked to spend the entire semester on the project instead of spending half the semester on mini-projects. We could have done similar assignments using just the project.
student 7	either offer more credits for communication or take it out completely. Not worth 1 credit.
student 8	The big project could be the main emphasis the entire class through.
student 9	Working on the way it blends with other courses
student 10	Lets the students either survey the site as a class or teach them how to use Civil 3D.
student 11	I think the professors would share the course load more evenly. Dr. Sarasua seemed to do most of the work and the other professors where not as co-ordinated as they could have been. I also wanted to use civil3d or similar applications more.

6

	HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?										
6.1	Attending lectures										
	student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
	5	5	5	4	5	5	5	5	5	5	5

6.2

Participating in discussions during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	5	5	5

6.3

Listening to discussions during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	5	5	5

6.4

Participating in group work during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	5	5	5

6.5

Doing hands-on classroom activities										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	5	5	5	5	5	5	5	5

6.6.1

Specific Class Activities										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	5	5	5	5	5	2	5	5

6.6.2

Creative problem solving activity										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	5	5	5	5	5	2	5	5

6.6.3

Design Charrette										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	5	5	5	5	5	5	5	5

6.7

Please comment on how the CLASS ACTIVITIES helped your learning.	
student 1	Bonding with classmates through activities allowed for easier learning environment
student 2	If you participated in the class activities, then the class was really easy. You knew exactly what to do for the assignments and most of the time you would finish the assignments in class.
student 3	I really enjoyed working with everyone in class and all the professors! Everyone got along pretty well.
student 4	N/A
student 5	Team building (obviously) assisted in helping my team and I learn how to work efficiently. Creative problem solving assisted in helping us come up with creative solutions to problems . The design charrette assisted in students learning how to communicate with stakeholders
student 6	This class was engaging and fun. The class activities made me feel like I was a part of a team and that professors wanted us to be do well.
student 7	PRepared us for final project.
student 8	All of the activities helped me see what civil engineers do for their jobs and with their coworkers and clients.
student 9	For the most part, they helped clarify the material
student 10	The class activities felt more of an overview of what we are going to learn in future classes. So it was kind of interesting.
student 11	The class activities allowed me to engage in the class more and better communicate with my classmates.

6.8

Please comment on HOW OFTEN YOU PARTICIPATED in class discussions and HOW THE ATMOSPHERE IN THE CLASSROOM ENCOURAGED OR DISCOURAGED your participation.	
student 1	I participated a fair amount in class and the class atmosphere was generally positive and encouraged my participation
student 2	I participated often. The class was very friendly and joking around a lot which never made me nervous to speak up or ask any questions.
student 3	I think I participated a pretty good amount, and definitely more so than I have in the past in other classes. The atmosphere definitely encouraged participation, which I liked.

student 4	N/A
student 5	I participated whenever possible. I saw this class as an amazing opportunity to gain a professional relationship with professors, a real understanding and knowledge of civ e, and a course that affects my GPA. What did not help my participation was the attendance of professors; sanders was almost always absent, even though he had many assignments due. Kaye and crocker were absent a few times, but not so greatly that it hurt my participation. Additionally, sarasua would be assisting one student, but teaching to the entire class and therefore distracting the rest of the class from their daily work.
student 6	I think pretty much everyone, including myself, participated in class discussions and activities. It was definitely an atmosphere that encouraged participation and made it easy to be engaged.
student 7	Everyone participated in lots of discussions.
student 8	I participated in discussions adding comments or asking questions on the topic.
student 9	I tried to participate often, and the closeness of the group made it easy
student 10	I participated less in the beginning, but after I got comfortable with the environment of the class I was not shy to participate.
student 11	I tried to participate as much as I could. The atmosphere in the class was very friendly and I felt comfortable participating as everyone was very engaged and enthusiastic about the project.

7 HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

7.1 Graded assignments (overall) in this class

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	3	5	4	5	4	5	5	3	5	5

7.2.1 Introductory Speech (baseline)

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	3	3	3	5	4	1	5	2	4	3

7.2.2 Informative Speech

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	3	5	3	5	5	1	5	2	4	4

7.2.3 Construction Management mini-project

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
2	4	4	4	5	4	5	5	3	5	4

7.2.4 Transportation Systems mini-project

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	3	5	5	5	5	2	5	4	4	4

7.2.5 Hydrology mini-project

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	3	5	4	5	5	2	5	5	4	4

7.3 Final project

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	5	5	5	5	5	5	5	5

7.4 The way the grading system helped me understand what I needed to work on

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	2	1	5	1	5	3

7.5 The feedback on my work received after assignments

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	4	5	2	2	5	1	5	3

7.6 **Please comment on how the GRADED ACTIVITIES helped your learning.**

student 1	I wish the assignments were graded in a more timely fashion so I had the opportunity to learn based off the grading.
student 2	The construction management activity really helped with how to do the final project, but the transportation and hydrology mini projects didn't seem particularly helpful.
student 3	We did graded activities after the lecture. I found these to be very helpful when learning the new material.
student 4	N/A
student 5	Sanders did not grade assignments until months after the assignments were turned in.
student 6	Some assignments were not graded in a timely manner which is frustrating because I'm not really sure where I stand in the class. This is stressful because a big portion of our grade comes from the project and final and I don't know what I had in the class going into that.
student 7	Certain assignments didnt help at all.
student 8	The structure of the grading helped tell me what the instructors were looking for.
student 9	They did not help at first because we did not really get them back until the final exam
student 10	It did not help much on the learning but it showed how much I need to refresh on CAD and excel.
student 11	Many of the construction management documents were not graded in a timely manner. The other assignments helped as a brief intro in the finals documents for the final project.

8 **HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?**

8.1 Online notes or presentations posted by instructor

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	4	5	5	5	4	5	5	5	4

8.2 Other online materials

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	9	5	5	5	4	5	4	5	5

8.3 Visual resources used in class (i.e. PowerPoint, demonstrations such as CAD, Excel, web resources)

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	4	4	5	5	4	5	5	5	4

8.4 **Please comment on how the RESOURCES in this class helped your learning.**

student 1	Resources helped visualize and present our findings
student 2	The powerpoints the professors used were posted online so we could always go back and check on the requirements or definitions. Also, Professor Crocker posted an outline for the informative speech which was a great help for meeting all of the requirements for that.
student 3	It seemed that the resources (lecture/assignment material) was simply taken from each professor's previous classes on the subject. This worked well, however sometimes the material didn't exactly line up with the assignment.
student 4	N/A
student 5	The resources we needed for the course we're always provided.
student 6	Helped me get an understanding of the application of hydrology in CE and why it is important.
student 7	Professors were quick to clear up any misunderstandings or help.
student 8	The resources helped me learn something I may have not known and to properly show off some of our ideas.
student 9	Having access to everything in canvas made completing the assignments easier
student 10	The softwares were used in a practical sense because all the previous classes we took on the softwares were not practical and felt like busy work.
student 11	The resources provided by the professors helped a lot and were what we used to guide our final project. The power points were also very helpful because we could reference them when working on the project.

9 **HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?**

9.1 Explanation of how the class activities, and assignments related to each other

student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	4	5	3	5	4

9.2

Explanation given by instructor of how to learn or study the materials										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	3	4	2	5	4	5	2	5	3

9.3

Explanation of why the class focused on the topics presented										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	4	5	4	5	5

9.4

Please comment on HOW the INFORMATION YOU RECEIVED about the class helped your learning.	
student 1	Seeing as this course is new for CE's new curriculum coming in the near future, it presented a good opportunity to develop some applications of civil engineering
student 2	We were informed of what would usually be required for professional engineers and then what was required for us, and they were very specific on our requirements which helped us complete assignments and we were never frustrated or confused.
student 3	The professors made it very clear how the material would help us in our careers.
student 4	N/A
student 5	The professors were all vague in what to study for the final; sanders gave a list that covered about 150 ppt slides. Kaye gave a list that mainly described pictures from a ppt. Sarasua essentially told us to study everything he ever went over. Crocker told us exactly what to expect so we would be prepared.
student 6	N/A
student 7	GAve a good outline of what to expect.
student 8	The information taught helped me to get a better understanding of the basic knowledge of civil engineers.
student 9	Learning about how these topics relate to the real world helped make them more interesting
student 10	Well transpo and water resource did not help with the overall project, but the construction management did.
student 11	We received all the information we need for the project. This helped because we did not have the base knowledge to know where to look for some of the documents we needed.

10

HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

10.1

Interacting with the instructors during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	5	4	5	5	5	5	5	5	5

10.2

Interacting with the instructors during office hours										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
3	5	3	4	2	5	5	5	5	5	9

10.3

Working with the teaching assistant during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	5	5	5

10.4

Working with the teaching assistant outside of class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	5	5	5

10.5

Working with peers during class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
5	5	5	4	5	5	5	5	5	5	5

10.6

Working with peers outside of class										
student 1	student 2	student 3	student 4	student 5	student 6	student 7	student 8	student 9	student 10	student 11
4	5	5	4	5	5	5	5	5	5	5

10.7 **Please comment on how the SUPPORT YOU RECEIVED FROM OTHERS helped your learning in this class.**

student 1	The TA's were fantastic in helping us, and our teammates encouraged one another with a common goal in mind.
student 2	Anytime I asked a question to anyone, they were immediately willing to help and help me understand in any way that I could and there was always a friendly atmosphere between everyone which made things less stressful.
student 3	Not only were the professors all great, but Nassim, our TA, went above and beyond to help us throughout the course. We could tell he truly cared and enjoyed helping us. We were finishing our final project the night before the presentation, and Nassim happened to be in Lowry. He stayed for about three hours late into the night to help both my group and another group finish their work and prepare to present. I've never had a TA be so enthusiastic and helpful in a class.
student 4	N/A
student 5	Sanders seemed to only be available during his office hours for us. Kaye, crocker, and sarasua were available in office hours, email, and in class. Nassim was available by email, in class, and out of class; he met me outside of class a few times to assist me, and it was greatlyappreciated.
student 6	Nassim was an awesome TA. I always felt comfortable asking professors for help. I worked with peers outside of class often, even for other courses that we were in.
student 7	Had an immense amount of support from professors, ta, and other students. Great teambuilding experience.
student 8	Getting help from others helped me to clarify any information I might have missed or needed to learn.
student 9	This class really encouraged team work and therefore it really helped to get help from others in and out of class
student 10	The professors were very helpful and seemed as excited as the class to help us with the project. I think both the professors and student both learned a lot from this.
student 11	Everyone involved in this class was very helpful and wanted us to succeed. The professors were always helpful and encouraging. students from other groups were also willing to discuss the project is we were lost or confused.

Appendix B

Springer Post Survey

Springer Post Survey									
1	As a sophomore starting out in civil engineering, Springer 1 gave me a better understanding of the different Civil Engineering subdisciplines and future courses that I could take.								
9 Responses		Avg:	4.44		Median	5.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	5	5	5	5	5	4	5	5	1

2	Springer's Transportation projects provided an improved understanding of the different Civil Engineering subdisciplines and future courses I could take.								
9 Responses		Avg:	4.33		Median	5.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	4	5	5	5	5	4	5	4	2

3	Springer's Water Resources projects provided an improved understanding of what to expect in future water resources courses (hydrology, fluids, etc.).								
9 Responses		Avg:	3.56		Median	4.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	2	4	4	4	4	4	3	4	3

4	Springer's Construction Management provided an improved understanding of what to expect in future construction courses.								
9 Responses		Avg:	3.67		Median	4.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	4	4	4	4	5	3	5	2	2

6	Did Springer 1 increase/decrease your identity as a Civil Engineer?								
9 Responses		Avg:	4.67		Median	5.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	5	5	5	4	5	4	5	4	5

7	As a sophomore starting out in civil engineering, participating in Springer 1 improved my sense of belonging in the CE department.								
9 Responses		Avg:	4.78		Median	5.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	5	5	5	4	5	5	5	5	4

8	After taking Springer 1, I felt (more or less) confident in my choice of major.								
9 Responses		Avg:	4.78		Median	5.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	5	5	5	4	5	5	5	5	4

9	Overall, I believe that Springer 1 should be a required course.				
9 Responses	Yes:	6	No:	3	

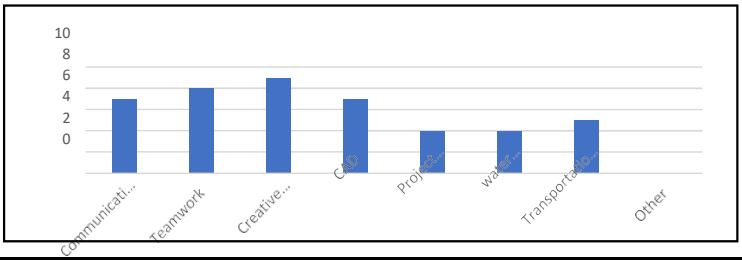
9.1	Why not?
Student 1:	Although I learned a lot and it was a fun class, I believe that the course curriculum will need significant improvements if the springer series continues as a requirement for all students.
Student 2:	This class should be an alternate option for students that want to take the classes covered in Springer 1.
Student 3:	The structure of the springer program is insufficient to make it a requirement at this time.

10	Do you believe Springer 1 should be a 2 or 3 credit hour course?				
9 Responses	2 credit hour:	2	3 credit hour:	7	

11	I feel more confident with my communication skills as a result of taking Springer 1								
9 Responses		Avg:	4.11		Median	4.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	3	5	5	4	5	4	4	3	4

12	Do you feel like teamwork skills learned in Springer 1 have benefitted you in other courses		
Teamwork questions	9 Responses	avg:	4.63
Creative problem solving	8 responses	avg:	4.50
Intercommunication between teammates	9 responses	avg:	4.75
Group presentations	9 responses	avg:	4.63
Time management skills	9 responses	avg:	4.38

13	What aspects of Springer 1 have you applied in other courses (Civil Engineering or otherwise)?							
Choices:	Communication	Teamwork	Creative problem solving	CAD	Project management	water resources technical content	Transportation technical content	Other
Responses:	7	8	9	7	4	4	5	0



14	Springer courses gave me a better idea of which civil engineering subdiscipline that I wanted to focus on.							
8 Responses		Avg:	4.25		Median	4.50		
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8
	5	5	5	5	4	3	3	4

15	The communication aspect of Springer 1 was an important part of that course								
9 Responses		Avg:	4.22		Median	4.00			
	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9
	4	5	5	4	5	5	4	2	4

16	How has Springer influenced your participation in other Civil Engineering courses?
Student 1:	Definitely feel more confident to take charge in any group project, I learned how to communicate better with others, and know how to hold people accountable with their responsibilities to the group.

Student 2:	I feel like I have gained more perspective on project management, transportation, and water resources.
Student 3:	I felt more confident completing group work (like lab reports) and participating in study groups.
Student 4:	Springer has given me a bit of a heads up on what to expect in future courses.
Student 5:	I am more comfortable speaking up when working in groups and asking questions pertaining to projects.
Student 6:	Coming into the course with an expectation based on what I learned in springer
Student 7:	Before participating in Springer, I barely knew any of my classmates or instructors. I just went to class, took notes, and studied on my own. Being in a smaller class setting really made me feel more connected to my instructors and realize that they genuinely wanted me to learn the material and get excited about it. I also became good friends with my classmates, and I continued to work and study with them throughout all my future courses.
Student 8:	I have felt that because of springer I am better able to work in groups, however, I think my participation in CI and internships had a larger effect on my current plans and courses I am taking
Student 9:	More confident in group work and sharing my opinion

17	How, if at all, has participating in Springer courses helped you in Junior or Senior level CE courses?
Student 1:	I haven't taken any
Student 2:	It gave me a basis for knowledge I would learn in future courses.
Student 3:	I've used some CAD skills learned in Springer both in CE work and at work.
Student 4:	It allowed me to understand Materials better than if I had otherwise not taken it.
Student 5:	Springer gave me a baseline understanding of my junior and senior level courses so I at least had some background knowledge when it came to my coursework.
Student 6:	Already knew what to expect from a material standpoint based on what I had been briefly exposed to in springer
Student 7:	Springer helped me to connect with peers who are also excited about Civil Engineering and want to get the most out of their courses. Springer shifted my perspective from just being focused on making good grades to being focused on truly understanding the material in my other courses. A lot of people will say that the stuff you learn in college doesn't matter, but I think the cool part about engineering is that it does matter. Springer helped me make that connection between school and the "real world."
Student 8:	Through springer I was able to group a couple of people that I work well with and take upper level courses with them so we can study and do projects together.
Student 9:	It has helped me in understanding parking design and working in a group.

18	Please comment on how your attitude of Civil engineering has changed going into your junior year due to springer
Student 1:	I feel I got a general idea what to expect and that class let's to develop a relationship with certain teachers that may teach for your future class. One of many benefits from Springer
Student 2:	It improved my attitude on how important civil engineering is.
Student 3:	Honestly I decided I didn't want to be an engineer but wanted to work in construction project management instead.
Student 4:	It has not changed.
Student 5:	I became more confident in my decision to be a Civil Engineer after taking Springer 1.
Student 6:	Was looking forward to taking classes I already knew something about
Student 7:	Springer made me think about my coursework as an important part of my future goals in Civil Engineering, and I have become more engaged in my other classes. It also helped me connect the things I am learning in school to a bigger purpose. Learning about stakeholders and why civil engineering is important to the community gave me a desire to learn as much as I can so that I can better serve others in the future.
Student 8:	I have felt more sure of my decision to pursue civil engineering and that I could find something that I find fulfilling.
Student 9:	My belief in that changing majors from mechanical engineering to civil engineering was the right move increased dramatically.

19	Do you feel like you were more/less prepared for future courses than peer students who didnot participate in Springer courses?
Student 1:	I don't see the course work actually helping, but the relationship we get from the professors helps a lot by knowing their style of teaching
Student 2:	I felt/feel more prepared.
Student 3:	I think that I gained more real life skills by working in teams with the other springer students, rather than being prepared more for future CE courses.
Student 4:	I felt like I was a bit more prepared.
Student 5:	I feel like I was more prepared.
Student 6:	A little bit more
Student 7:	More prepared. It was definitely helpful just to have some exposure and familiarity with subjects before getting into the super technical content.
Student 8:	I feel more prepared for my upper level classes as I have some prior exposure
Student 9:	More prepared.

20	In your opinion, do you feel like your education in civil engineering was different from peers who did not participate in Springer courses? If so, how?
Student 1:	More prepared.
Student 2:	Yes; I was allowed to have a sneak peak at what my later professors would teach me. Additionally, I learned how to combine subdisiplines before my classmates would
Student 3:	See answer to 20.
Student 4:	Not by that much. Springer does offer some opportunities to see more real world examples than in regular courses.
Student 5:	I feel as if I have more experience working on real world projects rather than just calculations.
Student 6:	Yes, because we were able to complete a project-based course encompassing many components that our peers had taken a whole class on.
Student 7:	Yes. I feel like a lot of my peers don't seem to be very interested or excited about coursework. It's not that everything I learn now is super exciting and fun, but I do often feel like I value the importance of it more than students who haven't participated in Springer.
Student 8:	I think the springer courses are very valuable and offer something that a typical civil engineering course does not offer.

21	Please comment on aspects of Springer 1 that you would want to ensure remain the same.
Student 1:	The group project and representatives come and review your project before it's actually done
Student 2:	Having a TA who is heavily involved in the course and with the students
Student 3:	I loved the small class size and being able to work closely with several professors and TA's all in different disciplines.
Student 4:	Keep a strong emphasis on transportation and giving presentations at design charettes or in front of your department.
Student 5:	The casual atmosphere, having a real world project to work on and the design charette.
Student 6:	Teamwork, material
Student 7:	Dr. Sarasua - he brings so much passion and energy to the course. Teamwork - I really benefited from working with my peers. Stakeholder meeting - it was really cool to talk to actual community members. A real life project - dealing with a real site that we could visit was really cool. Springer 2's project was way less intriguing because it just felt like another lab.
Student 8:	Multiple professors, real stakeholders, aspects from multiple fields.

22	Please comment on changes, if any, that you would want to make to Springer 1.
Student 1:	Not sure.

Student 2:	Make sure all the instructors are able to make it to class once a week, if not every meeting period. And if they can make it, that they do come to class even if they think they're not needed.
Student 3:	I would have preferred that the course material be prepared ahead of time and having a clear schedule and expectations, but understand that it was the first time that the course was being implemented.
Student 4:	I would make sure that most if not all the credits worth of material for Public Speaking were covered in the class.
Student 5:	I think there should be more organization and planning ahead. I also think it needs to be made clear how much time will be spent in class. For example, we were told we would have 1 hour one day, and 2 hours the other day but we ended up staying 2 hours both days and we were not planning on that.
Student 6:	Create a more well-structured program
Student 7:	I would have liked to have a little more introduction into the water resources discipline. I also wish we had started working on the project earlier in the semester.
Student 8:	Increase the amount of communication between the proffesors teaching the course

23	What is the worst thing about Springer 1?
Student 1:	The presentation in the beginning sucks. It's hard to present with people you don't know.
Student 2:	The confusion of what was happening because of a lack of communication
Student 3:	Unclear expectations of not only what we were expected to complete during the course, but also with what credit we would receive after completing the course.
Student 4:	I feel like there did not need to be a final exam. A final presentation is a perfect way to give a final grade in Springer 1.
Student 5:	The lack of organization in the beginning.
Student 6:	The uncertainty of the program
Student 7:	Comm, but I still preferred having to learn about Communication in that setting rather than in a non-engineering focused setting.
Student 8:	Seemed the course was being planned as it was happening

24	What is the best thing about Springer 1?
Student 1:	The students. I made a lot of friends from it and still to this day we talk and help one another with classes.
Student 2:	Nassim and Dr. Sarasua
Student 3:	I truly enjoyed working with everyone in the class and all professors and TA's. Everyone usually had a positive attitude and overall it was a good time coming to class. Although sometimes expectations were unclear, I never felt an unreasonable amount of stress while completing the assignments/project because I found the work interesting and relevant.
Student 4:	The transportation related content that was taught was interesting.
Student 5:	The casual atmosphere and the fact that the professors really listened to us when we were having issues.
Student 6:	Getting to know some peers in civil and getting a look into junior level courses
Student 7:	The best thing about Springer 1 was the atmosphere for stress-free learning through open communication with instructors, non-traditional coursework/grading, and teamwork.
Student 8:	The real life nature of the project

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