Pedagogical Updates of the Civil Engineering Freshman Course Sequence

Andrew Assadollahi, Ph.D., E.I., Christine Moore, and Raymond Eugene McGinnis, P.E.
Christian Brothers University, aassadol@cbu.edu, cmoore29@cbu.edu, gmcginni@cbu.edu

Abstract - **The Department of Civil and Environmental Engineering at Christian Brothers University has made several changes to its four year curriculum. The primary reason for these changes is due to the new format of the Fundamentals of Engineering Examination. The first phase of these major curriculum changes began with the freshman-level sequence of courses. Prior to the 2014-2015 academic year, the freshman sequence was comprised of three one-credit hour courses to be taken in the first three consecutive semesters of enrollment. After careful review of course evaluations, observation of student performance in later courses, consultation with current students, alumni, practitioners, and faculty at other universities which are accredited by the Accreditation Board for Engineering and Technology, Inc. (ABET); it was decided that a reorganization of these courses and their contents was necessary. These three courses were eliminated from the paradigm and replaced with a sequence of two two-credit hour courses. This research shows how the freshman sequence modification has impacted the students' performance in the sophomore-level courses of: Statics, Mechanics of Materials, Structural Analysis, Hydraulics, and Geomatics.**

Index Terms – Curriculum modifications, Civil Engineering Curriculum, Freshman Courses, Pedagogical Updates

INTRODUCTION

The first year at any academic institution is crucial for a student. Schluterman, Schneider, and Cassady (2010) [1] discussed the importance of the evaluation of engineering problem solving skills of first-year engineering students. The Department of Civil and Environmental Engineering (CEE Department) at Christian Brothers University (CBU) has made several changes to its four-year, undergraduate paradigm to address the idea that a positive introductory course sequence with thorough coverage of all of the branches within civil engineering is the best way to start a student's journey through a civil engineering department. The previous versions of the CEE paradigm contained three introductory one-credit hour courses known as "Introduction to Civil Engineering I, II, and III". All of these courses met once per week for 50 minutes. After careful review of course evaluations, observation of student performance in later courses (which these courses were prerequisites), consultation with current students, alumni, practitioners, and faculty at other ABET-accredited universities; it was decided that a reorganization of these courses and their contents was necessary. These courses were eliminated from the paradigm and replaced with CE 110 (Introduction to Civil Engineering) and CE 113 (Civil Engineering Analysis), which are both two-credit hour courses. These courses both meet for three lecture hours and one and a half laboratory hours per week. The objectives of the curriculum changes were to improve retention rates by developing an interest in civil engineering during the first academic year, set students up for success in later courses by providing more challenging material, and prepare students for ventures outside of the academic world such as internships and introductory-level engineering jobs. In the fall 2014 semester, the CEE Department at CBU was only comprised of 46 undergraduate civil engineering students. The goal is to reach an enrollment of 80 undergraduate civil engineering students by the fall 2018 semester.

Positive outcomes already looked promising by the new schedule alone. Table I shows the topics and the number of lecture and/or laboratory hours for each topic in the old freshman sequence (CE 101, 102, and 103) and in the new sequence (CE 110 and CE 113). The new freshman course sequence ensures over 67 more hours dedicated to learning introductory civil engineering topics compared to the old freshman course sequence. The change from one-credit hour classes to two-credit hour classes and a lab component allowed more time to accomplish the course curriculum objectives. The class and lab working together was expected to have multiple positive outcomes, engaging different kinds of students' learning mechanisms. The new freshman course sequence also has a continuous flow of topics, as opposed to the old freshman course sequence. The new freshman course sequence includes topics from geotechnical engineering that students would have otherwise not learned until later in their academic careers. The new freshman course sequence also better distinguishes between easier and more challenging topics from one semester to the next, ensuring a smoother transition of material delivery for students. This modification is positive for obtaining higher retention rates in the CEE department. All of these preliminary assumptions beg the question: "Did it work?" It was decided to conduct a survey to determine the magnitude and direction of the outcomes of these modifications.

OBJECTIVES OF THIS STUDY

The objectives of this study are to evaluate how the freshman course sequence modifications helped students in various aspects, and to look at how further modifications could be made for future students in the CEE department at CBU. A survey was sent out to students and alumni that went through the old freshman course sequence prior fall 2014, and an identical survey was sent to students that have been through the new freshman course sequence implemented in fall 2014, and have taken subsequent relevant courses.

IMPLEMENTATION OF COURSE MODIFICATIONS

I. Interest and Aptitude

A generally accepted procedure for finding an occupation that is adequate for a person is evaluating aptitude and interest in the subject. This is why people often take interest inventory tests along with skills tests when looking for possible careers. The freshman course sequence modifications followed this concept of optimizing both interest and skill in the classroom and accompanying lab.

II. Morale and Interest

The first issue that needed to be addressed was increasing retention rates by focusing on the overall enthusiasm of the students. The CEE Department at CBU has faced several challenges over the years with student retention during the freshman year. While having guest speakers come to talk with students about their professions is one way to peak a student's interest, more provisions needed to be made. This is partially why a lab component was added to the freshman course sequence. Students have seemed to enjoy the lab, as it gives them a more hands-on experience. By incorporating more hands-on laboratory content to the freshman course sequence, the tactile mode of learning is more thoroughly engaged. The department decided to create an Instagram account to increase student morale and interest, as well. Students often post pictures, tagging the CBU Civil Engineering Instagram page, giving the current students a sense of community and marketing to future potential students at the same time. Figure 1 shows students' response to the question: **"**How did your freshman course sequence affect your morale about the Department of Civil and Environmental Engineering?" Figure 2 shows students' answers to the question: "How did your freshman course sequence affect your interest in the subject matter of civil engineering?" Both of the figures show an increase in both morale and interest due to the modifications implemented in the freshman course sequence.

III. Preparation Outside of Academia

The next concern of the CEE department was student preparation for experiences outside of the academic environment. While knowing textbook material is important, there are some skills that are preferred but not required. Unfortunately, not all institutions teach these preferred skills, but it was decided that the CEE department at CBU would be one of them. This is why Visual Basic with Applications (VBA) in Microsoft Excel and a presentations component were emphasized and added, respectively, to the freshman course sequence. The previous freshman course sequence exposed students to the fundamentals of VBA and Matlab, but these skills were not emphasized significantly within the CEE Department at CBU. In the current freshman course sequence, the students first become familiar with the details of spreadsheet manipulations using Microsoft Excel during the fall semester (CE 110) course. During the spring semester (CE 113) course, students are taught how to write code using VBA within Microsoft Excel. VBA is considered to be very helpful in the civil engineering profession. Figure 3 illustrates students' responses to the question: "Do you feel like the use of Microsoft Excel skills obtained in your freshman course sequence has helped in later courses and/or internships?" From those results it is shown that implementing the use of VBA has been very helpful to students.

The previous paradigm only required one presentation during all of the three courses. It was decided that there needed to be a greater focus on presentation and communication skills for students. The CE 110 course (fall semester) has five oral presentations incorporated within the schedule and the CE 113 course (spring semester) has incorporated two oral presentations. Presentation requirements are rigorous compared to other entry-level courses. Students are expected to wear business appropriate attire, and come into class prepared with five-to-ten minute length presentations with professional formatting requirements. Figure 4 shows survey data on how students answered the question: "How do you feel that the oral presentation requirements of your freshman course sequence have enhanced your communication skills?" The data shows that students feel more confident in their ability to convey what they know to others. Figure 5 displays the responses from students that were asked the question: "Do you feel like your freshman course sequence prepared you to be successful at internships you obtained later?" The responses show noticeable improvement in the CEE department's students' ability to perform well in the workplace.

IV. Academic Success

The next concern of the CEE department was the students' performance in later courses and eventually the overall preparation for the Fundamentals of Engineering Exam (FE Exam). The mantra when attacking this issue was if students are challenged their first semester, they will expect the same in subsequent semesters, culminating in a more productive college career.

One of the first rigorous technical courses that students find challenging is Statics. This course has traditionally tended to persuade students into changing their major from engineering, thereby having a negative effect on retention within the department. It was believed that the cause of this

was due to a lack of a transition from the freshman course sequence to the sophomore level. To create a better transition, basic statics and linear algebra topics are now introduced to students during the second semester (CE 113) course. Students now learn concepts of solving systems of equations, matrix and vector mechanics, two-dimensional particle and rigid body equilibrium, average normal stress, truss analysis, as well as centroid and moment of inertia computations for composite bodies. Table 2 shows a comparison between the amount of class lecture time spent on statics topics in CE 113 with the complete list of statics topics covered in the three-credit hour Statics course (CE 201) at CBU. This table shows that CE 113 has a time-coverage of approximately 70% of statics topics covered in the CE 201 course. The outcomes of this modification are already showing to be positive. Figure 6 displays data obtained from students' answers the survey question: "How do you feel your freshman course sequence prepared you for statics?" The responses from the students who were enrolled in the old freshman course sequence compared to students enrolled in the new sequence are almost nearly inverses of each other.

Another subject that civil engineering students in years past struggled with was Geomatics (land surveying). Before the paradigm changes, the three-credit hour Geomatics course was taught during the second semester of the freshman year. Students tended to have a harder time understanding the material. When the freshman-sequence was updated, the Geomatics course was moved to the first semester of the sophomore year. An introduction to land surveying was incorporated into both the CE 110 and CE 113 courses so as to better prepare students for the three-credit hour Geomatics course. Figure 7 displays students' responses to the question: "How do you feel your freshman course sequence prepared you for Geomatics (land surveying)?" The survey results show a majority of the students in the new freshman course sequence felt positive about their preparedness for Geomatics; however, the data shows that there is still room for improvement with this subject matter.

The elusive class that still seems to be a daunting task for students is Hydraulics. Figure 8 displays students' answers to the question: "How do you feel your freshman course sequence prepared you for Hydraulics?" These responses show a slight improvement on students' feelings towards their preparedness for Hydraulics from the old freshman course sequence to the new freshman course sequence. Because the CEE Department faculty noticed students were struggling in the Hydraulics course during the second semester of their sophomore year, it was decided to include more material for the water resources component of the CE 110 course. Since Hydraulics is not taken until later in the students' paradigm, this was a more challenging undertaking. This is one area in which the CEE department can continue to improve. Currently there are plans to include more introductory water resource topics within both the CE 110 and CE 113 courses.

Mechanics of Materials and Structural Analysis are both critical analysis classes in civil engineering. These classes establish the foundation for the structural design courses. For this reason, success in these classes is pertinent for any student wanting to concentrate in structural engineering. The CEE Department wanted to prepare students in the best possible manner for these classes. This is where learning statics topics before the three-credit hour statics course becomes helpful. Since students have been exposed to 70% of statics topics during the second semester of their freshman year in the CE 113 course, the Mechanics of Materials course can be taught during the first semester of the sophomore year to civil engineering students. Consequently, this allows for more topics to be covered in the Structural Analysis course, which second semester sophomores take at in the CEE Department at CBU. Figure 9 shows students' responses to the question: "How do you feel your freshman course sequence prepared you for Mechanics of Materials?" and Figure 10 shows how students responded to the question: "How do you feel your freshman course sequence prepared you for Structural Analysis?" The results from both of these survey questions are noticeably positive. The data shows that students feel they have a better fundamental understanding of structural engineering topics from the new freshman course sequence.

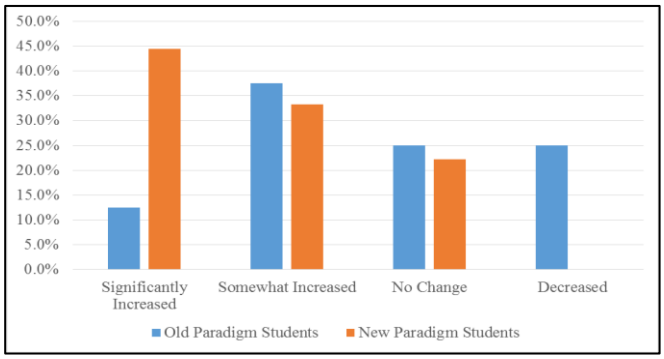

FIGURE 1
CHANGE IN STUDENT'S MORALE DUE TO FRESHMAN COURSE SEQUENCE MODIFICATIONS.

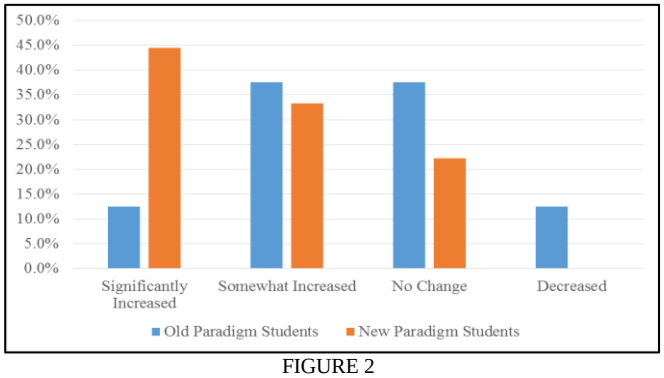

FIGURE 2
CHANGE IN INTEREST IN CIVIL ENGINEERING DUE TO FRESHMAN COURSE SEQUENCE MODIFICATIONS.

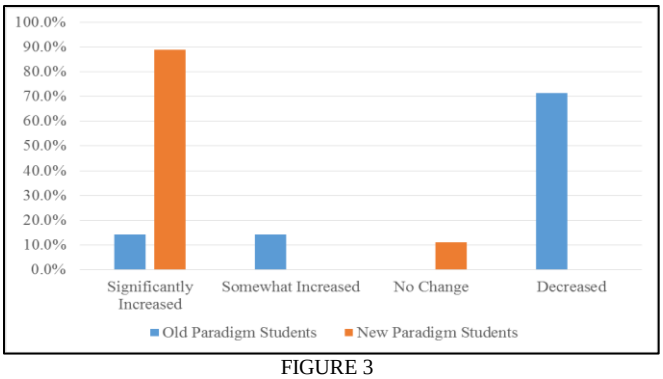

FIGURE 3
HELPFULNESS OF MICROSOFT EXCEL SKIILS OBTAINED IN FRESHMAN COURSE SEQUENCE.

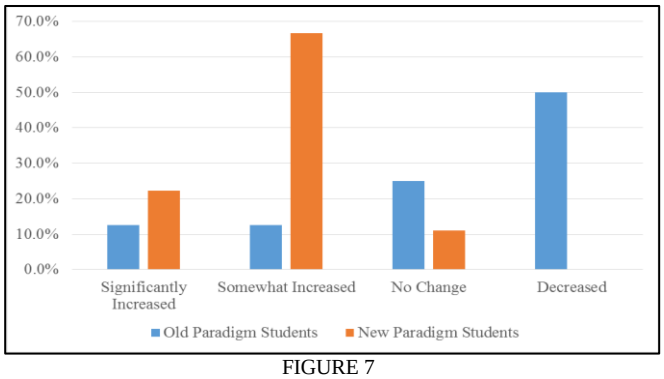

FIGURE 7
PREPAREDNESS FOR GEOMATICS AFTER THE FRESHMAN COURSE SEQUENCE.

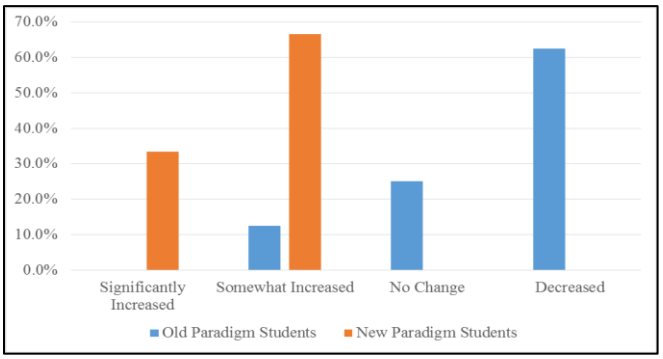

FIGURE 4
PRESENTATIONS IN THE FRESHMAN COURSE SEQUENCE AND THEIR EFFECT ON COMMUNICATION SKILLS.

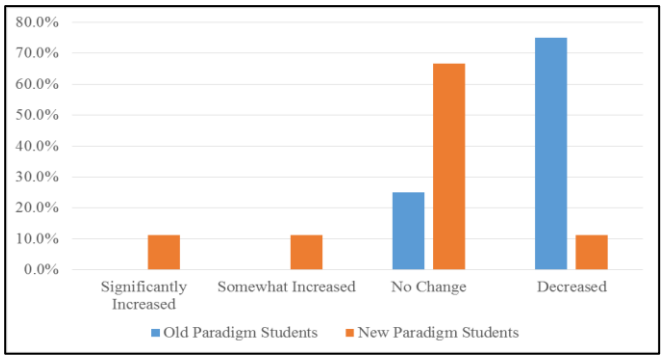

FIGURE 8
PREPAREDNESS FOR HYDRAULICS DUE TO FRESHMAN COURSE SEQUENCE MODIFICATIONS.

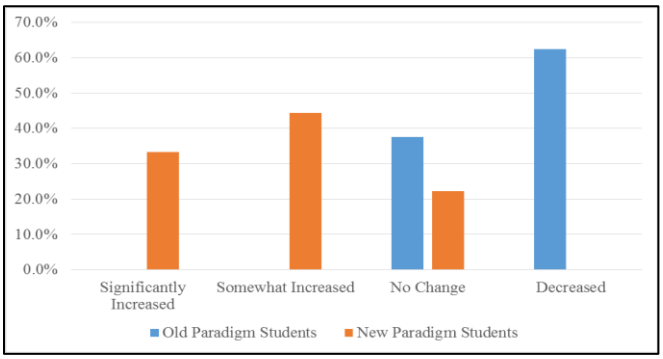

FIGURE 5
PREPAREDNESS FOR INTERNSHIPS AFTER THE FRESHMAN COURSE SEQUENCE.

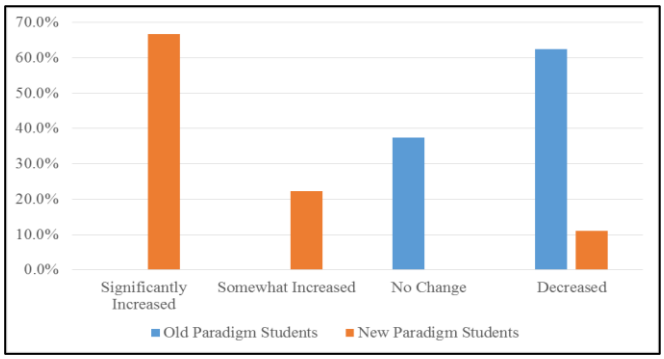

FIGURE 9
PREPAREDNESS FOR MECHANICS OF MATERIALS AFTER THE FRESHMAN COURSE SEQUENCE.

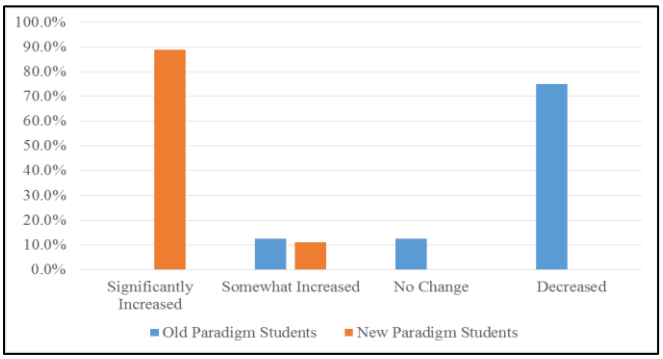

FIGURE 6
PREPAREDNESS FOR STATICS AFTER THE FRESHMAN COURSE SEQUENCE.

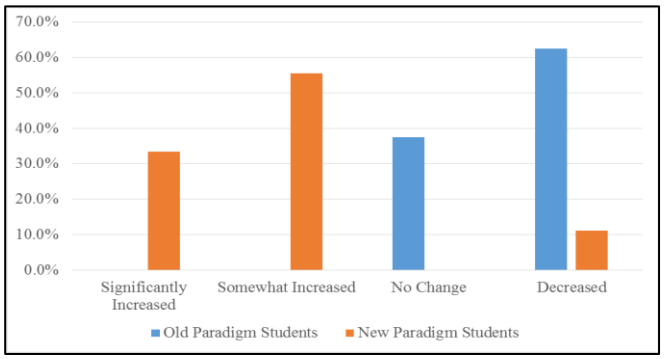

FIGURE 10
PREPAREDNESS FOR STRUCTURAL ANALYSIS DUE TO FRESHMAN COURSE SEQUENCE MODIFICATIONS

TABLE 1
TIME-COVERAGE OF TOPICS IN OLD FRESHMAN COURSE SEQUENCE AND NEW FRESHMAN COURSE SEQUENCE

TOPIC	OLD SEQUENCE			NEW SEQUENCE	
	CE 101	CE 102	CE 103	CE 110	CE 113
ENGINEERING DESIGN PROCESS	-	-	1.67	1.5	-
INTRO. TO STRUCTURAL ENGINEERING	-	3	-	4.5	-
CONCRETE MIX DESIGN/SLUMP TEST	-	3	-	6	-
COMPRESSIVE FORCE AND STRESS	-	1	-	3	-
TENSION/TORSION OF METAL AND WOOD	-	1	-	-	-
INTRO. TO TRANSPORTATION ENGINEERING	8	-	-	3	-
UNITS, FIELD NOTES, ERROR CALCULATIONS	-	-	-	4.5	1.5
DISTANCE MEASUREMENT	-	-	-	4.5	-
TRANSPORTATION PLANNING PROCESS	2	-	-	-	-
TRAFFIC DATA COLLECTION METHODS	2	-	-	-	-
DIFFERENTIAL LEVELING	2	-	-	-	10.5
INTRO. TO GEOTECHNICAL ENGINEERING	-	-	-	2.5	-
MOISTURE CONTENT	-	-	-	0.5	-
GRAIN SIZE DISTRIBUTION	-	-	-	4.5	-
PRELIMINARY SOIL CLASSIFICATION	-	-	-	1.5	-
INTRO. TO WATER RESOURCE ENGINEERING	-	-	0.8	0.75	-
WASTEWATER TREATMENT/PURIFICATION	-	-	3	3	-
PIPE AND OPEN CHANNEL FLOW	-	-	1.67	1.5	-
JAR TEST AND FILTRATION TEST	-	-	-	7.5	-
INTRO. TO ENVIRONMENTAL ENGINEERING	-	-	3	2	-
SOLID WASTE MANAGEMENT	-	-	1.67	-	-
EXCEL SPREADSHEET APPLICATIONS	-	1	1.67	6	-
HISTORY OF COMPUTERS/NUMBERICAL BASES	-	-	-	-	1.5
GEOGRAPHICAL INFORMATION SYSTEMS	-	-	1.67	-	-
SYSTEMS OF LINEAR EQUATIONS	-	-	-	-	4.5
MATRIX OPERATIONS, INVERSION	-	-	-	-	3
DETERMINANT OF A MATRIX/APPLICATIONS	-	-	-	-	1.5
TRIGONOMETRIC REVIEW/FORCE VECTORS	-	1	-	-	1.5
2D PARTICLE EQUILIBRIUM	-	1	-	-	3
BENDING MOMENTS AND COUPLE MOMENTS	-	-	-	-	4.5
UNIFORM AND TRIANGULAR FORCE DIST.	-	-	-	-	3
RIGID BODY EQUILIBRIUM	-	1	-	-	4.5
TRUSS ANALYSIS (METHOD OF JOINTS)	-	-	-	-	3
COMPOUND BREAMS AND FRAMES	-	-	-	-	1.5
AXIAL INTERNAL FORCES AND DIAGRAMS	-	1	-	-	1.5
INTERNAL TORQUE, SHEAR, AND MOMENT	-	-	-	-	3
CENTROID AND MOMENT OF INERTIA	-	-	-	-	4.5
TOTAL HOURS	14	13	15.15	56.75	52.5

TABLE 2
TIME-COVERAGE OF TOPICS IN CE 201 AND CE 113

TOPIC	CE 113	CE 201
TRIGONOMETRIC REVIEW/FORCE VECTORS	1.5	3
CARTESIAN VECTORS	-	1.5
POSITION VECTORS	-	1.5
DOT PRODUCT	-	1.5
EQUATIONS OF EQUILIBRIUM	3	1.5
2D PARTICLE EQUILIBRIUM	3	3
3D PARTICLE EQUILIBRIUM	-	1.5
MOMENTS OF A FORCE	1.5	0.75
MOMENTS USING VECTORS	-	1.5
CROSS PRODUCT	-	0.75
COUPLE MOMENTS	3	3.5
MOMENT ABOUT AN AXIS	-	1
UNIFORM AND TRIANGULAR FORCE DIST.	3	1.5
RIGID BODY EQUIL., FREE BODY DIAGRAMS	1.5	1
3D RIGID BODY EQUILIBRIUM	-	1.5
TRUSS ANALYSIS (METHOD OF JOINTS)	2	1.5
ZERO FORCE MEMBERS	1	1
TWO AND THREE FORCE MEMBERS	-	1
TRUSS ANALYSIS (METHOD OF SECTIONS)	-	0.5
COMPOUND BREAMS AND FRAMES	1.5	1.5
FRAMES AND MACHINES	-	1.5
AXIAL INTERNAL FORCES AND DIAGRAMS	1.5	0.5
INTERNAL TORQUE AND DIAGRAMS	1.5	-
INTERNAL SHEAR AND MOMENT AT A POINT	1.5	1
FRICTION	-	3
COMPOSITE BODY CENTROID	1.5	3
COMPOSITE BODY MOMENT OF INERTIA	3	3
TOTAL HOURS	30	42.5

CONCLUSIONS

This study accomplished its objectives by surveying students from both the old and new freshman course sequences and reviewing syllabi from both the old and new freshman course sequences. The results not only confirmed the initial hypothesis that noticeable improvements have been made to the freshman course sequence, but also showed areas that still have room for improvement. The CEE Department is already using this data to improve the Geomatics and Hydraulics material for the fall 2016 semester. Going into the future, the authors will continue to collect data from students and monitor student success from the freshman course sequence.

ACKNOWLEDGMENT

The authors would like to thank the CEE Department and the entire School of Engineering at CBU for their continuous support in the modifications and improvements of the civil engineering curriculum. The authors would also like to thank all of the students and alumni who have been involved in the data acquisition and processing during this study.

REFERENCES

[1] Schluterman, H. A., Schneider, K., and Cassady, C.R. (2010) "Evaluating Engineering Problem Solving Skills of First-Year Engineering Students" *ASEE Midwest Section Conference, Lawrence, KS, 2010.*

AUTHOR INFORMATION

Andrew Assadollahi, Ph.D., E.I., Assistant Professor, Christian Brothers University, 650 East Parkway South, Memphis, TN 38104, aassadol@cbu.edu
Christine Moore, Undergraduate Research Assistant, Christian Brothers University, 650 East Parkway South, Memphis, TN 38104, cmoore29@cbu.edu
Raymond Eugene McGinnis, P.E., Associate Professor and Department Chairman, Christian Brothers University, 650 East Parkway South, Memphis, TN 38104, gmcginni@cbu.edu