Importance and Sequence of Laboratory Course in Environmental Engineering: A Case Study

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Abstract

A university study in science/engineering, devoid of a practical component such as laboratory work, is virtually unthinkable and is not be acceptable to ABET accreditation process. One could even go so far as saying that it is extremely rare for anyone to question the necessity of laboratory work in university science/engineering curricula. Laboratory work is an essential part of the science/engineering game that needs hands-on experience and learning process. This article is primarily directed at a clarification of sequence of environmental engineering laboratory offerings as well as group learning experience in a lab course at a University setting based on the students' perception and attitude. Based on the responses of 102 students out of 133 students in the class, it appears that students' perception and attitude towards offerings the environmental engineering lab and the lecture in the same semester appeared to be favorable. But no inference could be drawn for the experience they gained from group work in the lab class, although overall group learning experience seems to be favorable with a scale of 3.76 on a 5.0 scale based on summer 2016 and fall 2016 data.

Keywords

Environmental engineering lab, sequence of offerings, students' perception and attitude

Introduction

Laboratory is considered to be an integral part of the courses that require the understanding of the concept of field applications with data collection, analysis of data, and the application of data in the system design. Environmental engineering is such a branch of engineering that cannot be understood properly without the laboratory component. But how this same laboratory can best be used/offered in the instruction of future scientists/engineers is still somewhat an unanswered and, sometimes hotly disputed. Flansburg[1] found that, while new curricula stress the processes of science, emphasizing higher cognitive skills such as concept attainment, problem solving and critical thinking, students completing science courses involving laboratory work can do little, if any, better on examinations than students completing equivalent courses not involving laboratory work.

As a matter of fact, though experiments may aid in postulating a problem, they sometimes prove not only to be superfluous but actually harmful in achieving those skills which they hope to be helpful in attaining. Kreitler and Kreitler[2] attribute this harmful effect to the diversion of the

learner's attention from the essential theoretical features of the problem with a concurrent fixation of attention on "salient aspects" of the concrete situation. It seems that we are confronted with a paradox. A degree in the natural sciences (physics, chemistry, biology) that does not include a rather large amount of laboratory work (measured mostly in time spent in a laboratory) is considered at best a "second-rate" degree. At the same time, it sometimes seems that the only skills which this laboratory work appears to excel in achieving are the lowly-regarded manipulative skills[3]. Why then do we insist on long hours of laboratory work? Although this problem is particularly salient at institutions dedicated to distance education, it is quickly becoming current at regular universities and (poly)technical colleges and universities. There is a move among administrators to either discontinue or cut back on laboratory instruction in undergraduate science courses[4]. According to them, the basic arguments for this movement are:

- Laboratory instruction is very expensive, both for personnel and for material.
- The laboratory and laboratory instruction is not generally perceived of as a worthwhile learning experience.

The unique contribution of practical work in science instruction should be its ability to aid in the development of conceptual thinking, stir the imagination, whet the appetite and hone the methodological sharpness of those taking part in the experimental experience[4]. Is it really happening in engineering lab teaching? What can be done in the engineering labs to make the experimental learning more attractive? Although this study didn't focus on these two questions, these questions could be explored in the future studies. We all engineering educators will admit that in engineering education, laboratory experience is necessary to consider as hands-on experience that meet the ABET requirements and the best we can get during student life.

Traditionally the role of the laboratory course in engineering has been for the student, either through demonstrations or hands-on experimentation, to reinforce the concepts discussed in lectures or read from the textbook. Rationally, learning through the laboratory depends significantly on the nature of the experience. Flora and Cooper[5] concluded that neither group size nor selection criteria impacted how well students worked within their groups. Their study found that by utilizing open-ended questions in the survey, a significant portion of student responses indicated that they enjoyed the experience of inquiry-based laboratory experiment in undergraduate environmental engineering laboratory.

This article discusses the importance and sequence of environmental engineering laboratory offerings in civil engineering program as well as importance of group learning using a student survey based on the students' perception and attitude. A required lab course, Introduction to Environmental Engineering Lab, for civil engineering program, was used to conduct this study. No performance assessment was done in this study.

Study Methodology

At the end of the semester of each lab, an on-line anonymous survey was conducted with six questions to understand the student perception and attitude about the lab course and the sequence of lab offering with the lecture course. Please note that the survey was conducted with hard questions in Fall 2014 and on-line using Desire-2-Learn (D2L) in the subsequent semesters. The questions are presented in Figure 1. The data were collected for four semesters, Fall 2014, Fall 2015, Summer 2016, and Fall 2016. As shown in Table 1, there are a total of 133 students

enrolled in the course during these four semesters and 102 (about 77%) students participated in the survey. Thirty one (31) students did not take the survey due to the fact that the on-line survey was not mandatory and no incentive/point was given to take the survey.

Q.1. Did you take any CE lab class before? □ Yes □ No

Q.2. Are you male/female?

O Male O Female

Q.3. What is your class status?

O Senior O Junior O Sophomore

Q.4. Are you taking the lab and the course in the same semester? □ Yes □ No

Q.5 Do you think that it's advantageous to take the lab and the lecture class in the same semester as the theory part helps the lab and vice-versa?

- o Strongly Agree
- o Agree
- o Neutral
- o Disagree
- o Strongly Disagree

Q.5. Rate your learning experience working in a group in the lab (5 being the highest)?

O 1 O 2 O 3 O 4 O 5

Q.6 Please provide any comments/suggestions/concerns about the sequence of lab and the theory class offerings as well as about your learning experience in a lab group.

Figure 1: Survey questionnaire for Environmental Engineering lab offerings

Table 1: Student enrollment and other information semester by semester

	Fall 2014			Fall 2015			Summer 2016	Fall 2016		Total	Taken the course and the lab in the same semester?	
Enrollment	15	15	15	15	15	12	16	15	15	133	YES	NO
Participants	15	15	15	7	10	6	13	12	9	102	82	20
% Participants	100	100	100	46.67	66.67	50.0	81.25	80.0	60.0	76.69	80.39	19.61

The analyses of survey data are illustrated in Figures 2 through 7. Please note that some of the responses to questions/options/choices, as seen in the Figures, might not sum up to 100% as a few students might not respond to all questions or options or choices.

Data Analysis, Results, and Discussion

Based on the responses to Q.1, overall about 80% took any lab in civil engineering (CE) before and about 20% did not take any kind of CE lab before while they were taking the Environmental Engineering lab (Figure 2). The participants were not well distributed with and without any prior exposure of CE laboratory. This could be due to the fact that everyone in environmental engineering lab class is either senior or junior as shown in Figure 3. However, the study did not separate the effect of prior exposure to CE laboratory courses in this study as the survey was anonymous and combination face-to-face written and on-line using learning management system (LMS) where the responses from different group cannot be separated without additional questions. Also please note that the study did not look into the effect of gender (Figure 4) in lab offering sequence and group learning experience for the same reason mentioned earlier. Similar to prior exposure to CE lab courses and gender, the study did not look into the effect of class status due to the same reason. However, Figures 3 and 4 are provided as informational that indicate the typical distribution of students' academic standing in the class and presence of female students in our engineering programs, respectively. Overall about 92% participants were senior, about 8% junior, and no sophomore as the course is a higher level engineering course. The overall female participants were about 25% in the lab although some semesters such as summer 2016 showed about 45%.

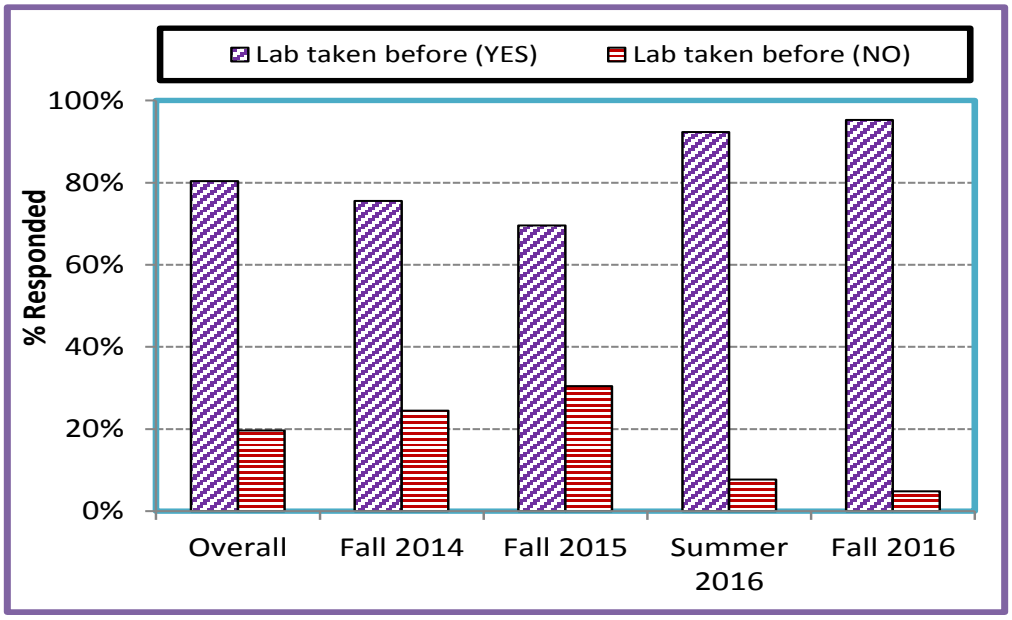

Figure 2: Distribution of participants for prior exposure to CE laboratory

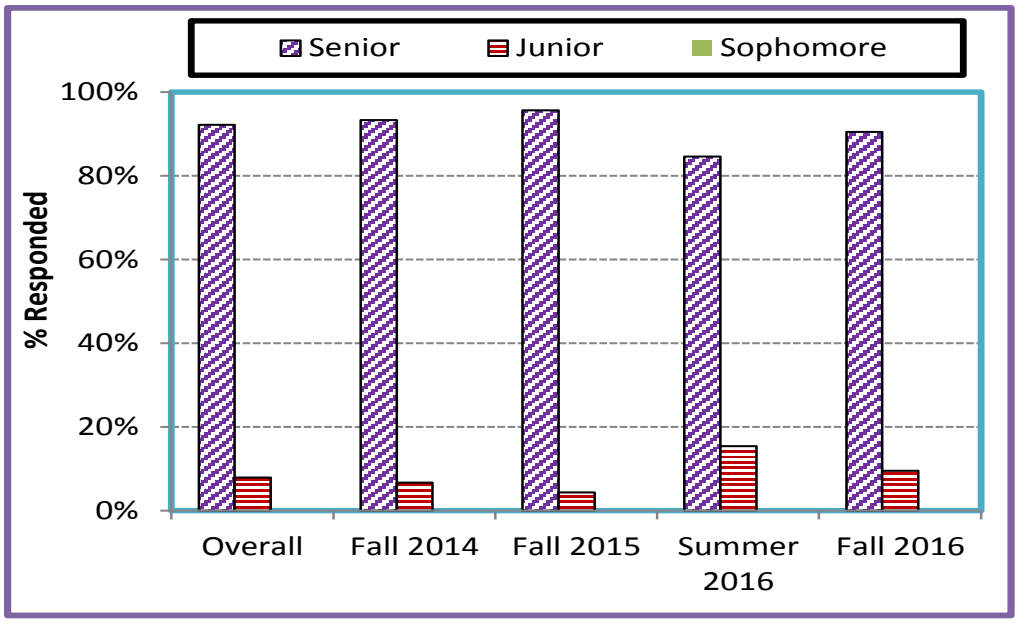

Figure 3: Distribution of participants showing the class status

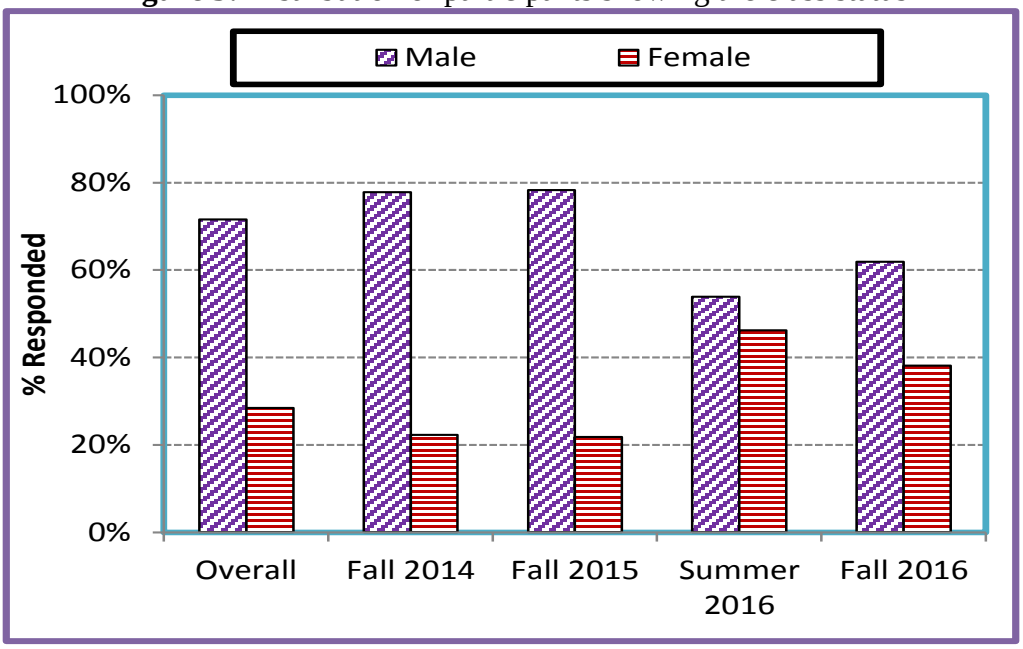

Figure 4: Distributions of male and female participants in the survey

In response to Q.4, "Do you think that it's advantageous to take the class/theory and lab in the same semester as the theory part helps the lab and vice-versa?", overall 52% participants, who took the class and the lab in the same semester, strongly agreed, and about 24% agreed, about 15% were neutral, 7% disagreed, and 2% strongly disagreed as shown in Figure 5. Overall 76% participants somewhat agreed that taking the class and the lab in the same semester was helpful. The finding would help set up the lab course as either co-requisite to the theory or prior completion of the theory. Based on the participants' agreement (about 76%) it seems that co-requisite would be a good option, but due to time conflict, lot of students might not be able to take the lab and the lecture in the same semester, and hence the students would fall behind one semester that might ultimately defer their graduation. Therefore, lab course set up as co-requisite

to the lecture or prior completion of the lecture would be the best option as this option would allow students to take them in the same semester or take the lecture first and then the lab, based on their schedules. This set up option would also help the programs that use only the lecture class and not the lab in their curriculums to avoid overrides for the lecture during registrations.

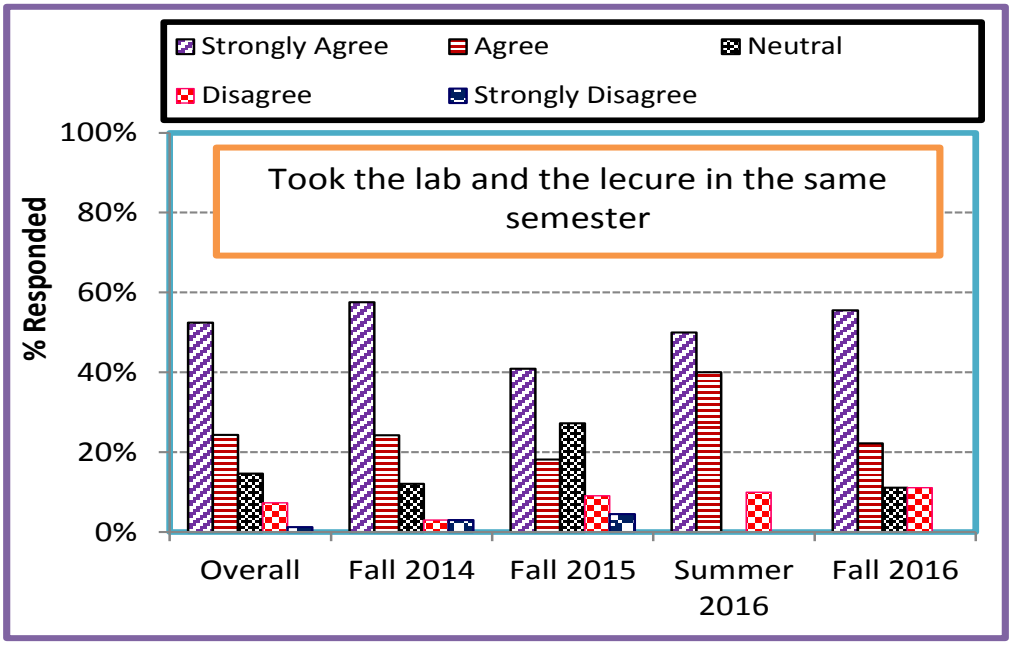

Figure 5: Distribution of participants, who took the lab and the lecture in the same semester, showing the agreement on advantage of taking the lab and the lecture in the same semester

In response to Q.4, overall no participants, who took the lecture and the lab in different semesters, strongly agreed, about 30% of the participants agreed, about 55% were neutral, 10% disagreed, and only 5% strongly disagreed as shown in Figure 6. Majority of the participants in this category (about 55%) did not feel that taking the lab and the lecture in the same semester was advantageous or disadvantageous. About 15% of the participants felt like advantageous of taking the lab and the lecture in different semesters which is far less than that of the 76% participants, who took the lab and the lecture in the same semester and felt advantageous and helpful. As mentioned earlier and shown in Table 1, about 80% of the participants took the lab and the lecture in the same semester and only 20% of the participants took the lab and the lecture in different semesters and 76% of the participants of these 80% participants (Figure 5) somewhat agreed that taking the lab and the lecture in the same semester was advantageous and helpful. Therefore, argument in favor of taking the lab and the lecture in the same semester seems to be more representative and reasonable.

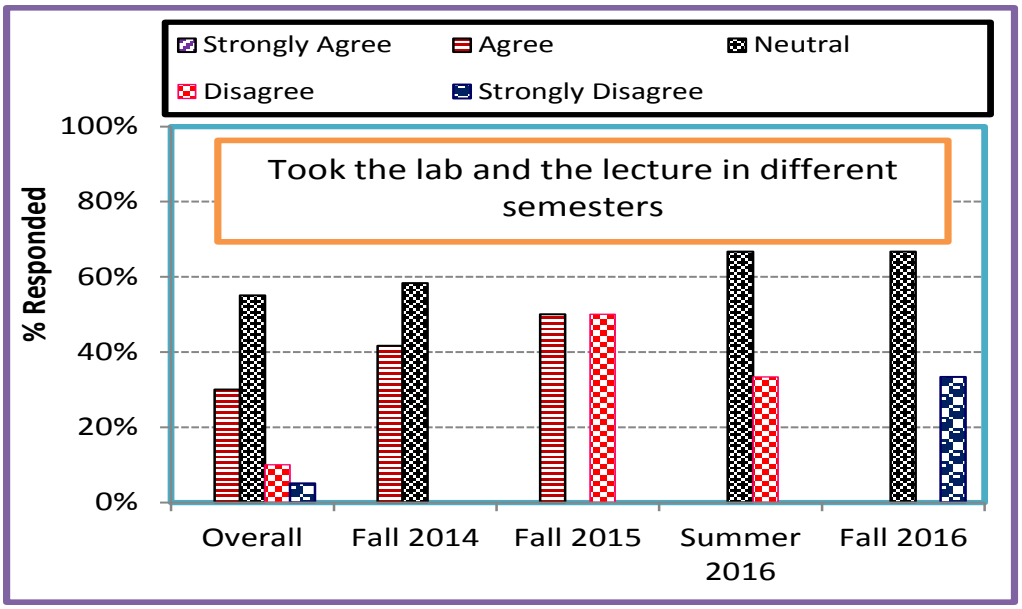

Figure 6: Distribution of participants, who took the lab and the lecture in different semesters, showing the agreement on advantage of taking the lab and the lecture in the same semester

The Q.5, "Rate your learning experience working in a group in the lab (5 being the highest)?" was included late in the study just for Summer 2016 and Fall 2016. Based on the responses to Q.5 as to how the participants experienced in group learning, about 27% of the participants chose "5" scale, 33% chose "4" scale, 27% chose "3" scale, 13% chose "2" scale, and 0% chose "1" scale, as shown in Figure 7. No participants omitted this question. The weighted average of the choices were about 3.76 for overall, 2.60 for summer 2016, and 3.62 for fall 2016. It appears that no inference can be drawn as to how the group works in the lab help the students in their learning, although overall group learning experience seems to be favorable with a scale of 3.76 on a 5.0 scale based on two semesters' data.

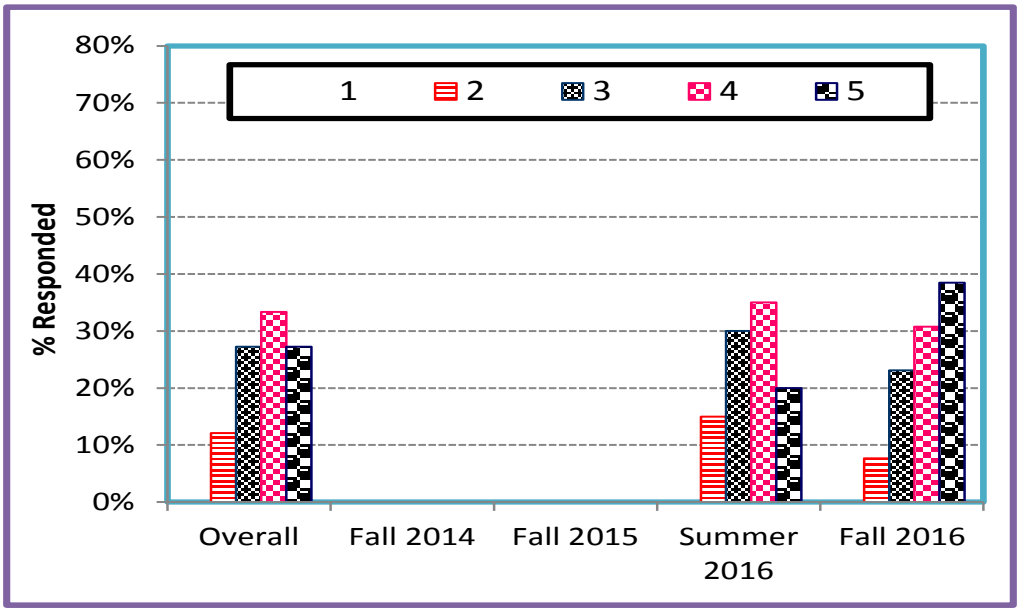

Figure 7: Distribution of participants' choices for group learning experience

The typical comments received for open ended Q.6 are quoted below. Most of the participants responded to this question. However, only a few pertinent comments and one of the similar responses are quoted below for this question.

"The lab is very helpful in better understandings the theory."
"I took the lecture in different semester. I think taking the lecture with the lab would be have been helpful."
"Lab is a great visual of what we learn in lecture."
"I don't feel that the lab helps me understand the lecture or vice-versa."
"You will forget the materials if you don't take them in the same time."
"Definitely easier when together, like salt and pepper."
"I can see what actually is happening in the theory."
"Fun lab that is very informative."
"I think everything is good. I enjoy learning this course and the lab same semester."

Summary and Conclusions

In this paper, an effort was made to assess the perceptions and attitudes of students, which influence the group learning experience and sequence of lab offerings in environmental engineering for civil engineering program students. The lab course, `Introduction to Environmental Engineering Lab', was used to conduct this study. At the end of the semester, a face-to-face written and/or an on-line anonymous survey was conducted with six questions to understand the students' perception and attitude about the sequence of lab offerings as well as group learning experience in environmental engineering lab. Based on the survey data analysis, students' perception and attitude towards offerings of an environmental engineering lab and the lecture in the same semester appeared to be favorable. But no inference could be drawn for the experience they gained from group work in the lab class, although overall group learning experience seems to be favorable with a scale of 3.76 on a 5.0 scale based on the summer 2016 and fall 2016 data. According to Flora and Cooper[5], the study could be augmented using inquiry-based laboratory experiment to make the experiment learning attractive and enjoyable.

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Dr. Karim spent about six years as a full-time faculty at Bangladesh University of Engineering and Technology (**BUET**) after his graduation from the same university in 1989. He came to USA in 1995 and finished his Ph.D. in Civil/Environmental Engineering from Cleveland State University in 2000. He worked about three years for ALLTEL Information Services in Twinsburg, Ohio as an Applications Programmer. Then he worked about eight years (in two different times) for the Virginia Department of Environmental Quality (**VDEQ**) as a Senior Environmental Engineer and taught at Virginia Commonwealth University (**VCU**) as an Affiliate Professor before he went to Trine University in January 2008, as a full-time faculty of Civil & Environmental Engineering. He taught part-time at Indiana University-Purdue University Fort Wayne (**IPFW)** while employed at Trine University. During his time at Trine University he taught an online course for VCU. He also taught at Stratford University, Richmond, Virginia campus as an adjunct faculty while working for VDEQ. Since fall of 2011, Dr. Karim has been working for Kennesaw State University, Marietta Campus, Georgia as a full-time faculty in Civil and Construction Engineering. He is a registered professional engineer for the State of the Commonwealth of Virginia and the state of Georgia. He has more than twenty journal and proceeding publications and three professional reports in the area of soil and sediment remediation, environmental management, statistical hydrology, project-based learning (PBL), and engineering education. He is a member of American Society of Civil Engineers (ASCE), and American Society for Engineering Education (ASEE). He is also an ABET EAC Program Evaluation Volunteer (ABET EAC PEV) for CE program.