Inclusion of Field Trips in Teaching of Environmental Engineering for Civil Engineering Program: A Case Study

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Abstract

The course, `Introduction to Environmental Engineering', was developed and taught incorporating the field trip in the course curriculum. In this course, two field trips were arranged: one in a local water treatment plant after finishing the topic water treatment and drinking water standards and the other in a local wastewater treatment plant after finishing the topic wastewater treatment and disposal. The data was collected based on the options: no incentive, incentive for overall grade, and/or bonus points for overall grade that was assigned in the field trips for three different semesters. At the end of the semester, an anonymous on-line survey was conducted with five questions to understand the perceptions and attitudes of students that had participated in the field trips. To assess the students' understanding about the water and wastewater treatment processes, one question was set in the midterm exam to draw a flowchart for a typical water treatment plant and another question was set in the final exam to draw a flowchart for a typical wastewater treatment plant. Based on the collected data, students' perceptions and attitudes about field trip appeared to be favorable and acceptable as a learning environment of water and wastewater treatment processes. Based on the assessment of flowchart questions, field trips had some effect as a learning tool in terms of knowledge retention about water and wastewater treatment processes.

Keywords
Environmental engineering, Field trip, Students' perception

Introduction
A field trip is a group of people that journey to a place away from their normal environment usually for observation to provide students with experiences outside their everyday activities[1]. It could be tied to a course learning or independent of course learning. By incorporating students into the design and implementation of field trips, faculty can engineer an environment where student and teacher encourage and learn from one another in an environment not tied to any particular class or for any course credit. The strategy operates on the premise that frequent and regular contact of faculty with students outside the classroom environment results in opportunities for both groups to not only become actively involved in learning but also to see themselves as resources for each other's personal and educational growth and development.

In environmental engineering courses, it would be an ideal if students could be taken on tours to water and wastewater treatment plants, solid waste disposal landfill, composting facility, materials recovery facility (MRF), transfer station, hazardous waste treatment facility, universal waste recycling facility, medical waste treatment facility, and so on. Unfortunately, it would

clearly be impossible to take everybody in a group of students on such trips, because of the lack of motivation, time constraints, cost, scheduling, and logistic limitations.

As general education class sizes increase, so do the cost, liability, and difficulty of running a field trip. A solution for economically and conveniently bringing kinesthetic field experiences to a broader audience lies in the integration of technology through mobile-device games, apps, and augmented reality (AR) field trips[2]. This study reported an examination of learning gains at five colleges after intervention with augmented reality field trips to Grand Canyon. The AR field trips cover three topics taught in introductory geoscience courses: geologic time, geologic structures, and hydrologic processes. Results involving nearly 1000 students show that overall gains are similar to control groups, with completion of the AR field trips being a predictor of student learning success in some cases.

A commentary[3] published in Geoscience stated that the geosciences benefit from diverse student perspectives and backgrounds, but the field-based learning requirements pose barriers to students with disabilities. If carefully designed, fieldwork can be made accessible while still meeting expectations of academic rigor. Students with disabilities felt concerns about fieldwork prior to and during university[4], and also reported feelings of exclusion[5,6]. There was also a perception in the geoscience community that students with disabilities were actively discouraged from participating in geoscience[7].

Field trips can be considered as visual learning depending on the type of learner. An area where visual learning is explored in some depth is algorithm visualization in computer science, which is the basic area studied by several researchers[8], although they intended their hypotheses and approach to be more general. McGrath and Brown (undated)[9] examined the emergence of Visual Learning in Science and Engineering, an important methodology for learning and understanding scientific principles. They highlighted successful activities in classrooms throughout the world and pointed out some areas where more work was needed. The goal of their study was to encourage faculty in STEM disciplines to use visual methods to communicate about science and engineering. Their findings suggested that engineering education must be fundamentally revised to include visual thinking throughout the curriculum. Drawing and sketching are important techniques to accomplish this and should be included in the student's experience. Based on this study, field trips could be an effective tool for learning.

Another study[10] evaluated the content of an Environmental Science field trip. This study conducted a quantitative analysis on two field trips to a science center that represented an ecological oriented program and an environmental issue presentation. They chose two variables as indicators of program success - knowledge retention and attitude change - are outcomes that have been found prevalent in informal, environmental science education. The results of this study showed significant gains in science related knowledge following both the ecology and issue oriented treatments. The data indicated that the focus of the program (ecology or issues) did not significantly alter the way students responded to the knowledge section of the evaluation instrument. Results showed little impact on students' affect toward park site or related subject matter following either presentation type.

A significant amount of literature also suggests that informal science field trips create a positive impact on affect. "Learning in informal science education facilities may potentially span all three learning domains. However, there is both professional opinion and empirical research which suggest that the major advantages of learning activities in informal educational settings over those in formal settings may lie in affective domain"[11].

The goal of this study was to evaluate the students' perceptions and attitudes about field trips approach as a part of learning environment of water and wastewater treatment processes that could be tailored for future environmental engineering courses as well as to assess the effect of field trips on the treatment processes as a learning tool in terms of knowledge retention. The students were asked to pay attention to the presentation by the plant managers/operators, look at the treatment processes closely, and take notes for reference, during the field trips.

On-line Survey

At the very end of the semester, an on-line anonymous survey was conducted with five questions (Figure 1) to gather the students' perception and attitude about field trip to learn environmental engineering. To assess the students' understanding about the water and wastewater treatment processes, one question was set in the midterm exam to draw a flowchart for a typical water treatment plant (WTP) and another question was set in the final exam to draw a flowchart for a typical wastewater treatment plant (WWTP). The types of questions set in the exams are presented in Figure 2. The data were collected for three semesters, spring 2017, summer 2017, and fall 2017. There are a total of 84 students enrolled in the course during these three semesters and 79 students (94%) participated in the survey. Five students (6%) did not participate in the survey. The high turnout is due to the fact that although the survey was not mandatory but 5 bonus points were given to take the survey. Out of 79 respondents in the survey, only 54 students (68%) participated in the field trips. The low turnout could be due to the fact that the field trips were not mandatory for spring 2017 and fall 2017 except for summer 2017. First semester (spring 2017), the trips were optional with no incentive. Next semester (summer 2017) field trips were required with 10% of the overall grade. Next semester (fall 2017) field trips were optional with 10 bonus points. The analysis of survey data is illustrated in Figures 3 through 6. Please note that some of the responses to questions, as seen in the Figures, might not sum up to 100% as a few students did not respond to all questions.

Q.1. Did you participate in the field trips? ☐ 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. If you participated in the field trips, do you think that these field trips enhanced/ improved your understanding and learning of Environmental Engineering (5 being the highest)?

O 1 O 2 O 3 O 4 O 5

Q.5 Please provide any comments/suggestions/concerns about the pros and cons of field trips that you may have.

Figure 1: Survey questionnaire for inclusion of field trips in Environmental Engineering

Midterm Exam:

Q.6. As an engineer you were hired by the City of Austell Department of Public Works to evaluate a source of water for drinking water supply. Their preliminary study shows that surface water is the best source of supply for them. However, surface water appears to be very colored with very high total solids (suspended + dissolved). Draw a flow chart with the treatment options that may be suitable for treating the surface water. Label each individual unit treatment process you will suggest for the treatment. (CLO 4)

Final Exam:

Q.2. As an engineer you were hired by the City of Marietta Department of Public Works to evaluate a treatment process for the wastewater the City generates. Their preliminary study shows that the wastewater contains high BOD_5, SS, and no nutrients as the City does not maintain a combined sewer system. Draw a flow chart with the treatment options that may be suitable for treating the wastewater. Label each individual unit treatment process you will suggest for the treatment. (CLO 6)

Figure 2: Exam questions for understanding of water and wastewater treatment plant processes

Data Analysis, Result, and Discussion

Based on the responses to Q.1, overall about 68% participated in the field trips, 32% did not participated in the field trips, and only 1% did not either respond or participated in the field trips or this could be a rounding error (Figure 3). The participants were distributed among three semesters. Highest participants were in summer as the trips were mandatory with 10% overall grade. Spring semester was the lowest in participants. This makes sense, as there was no incentive for field trips either as bonus points or as required points for the overall grades.

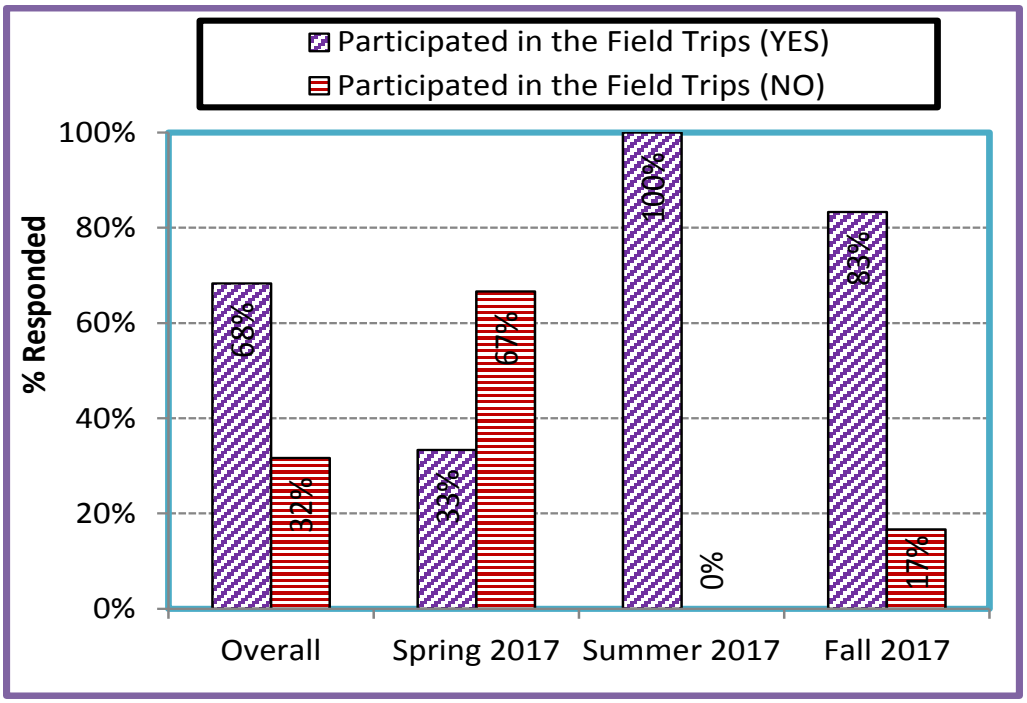

Figure 3: Distributions of response for participating and not participating in the field trips

The distributions of the responses for Q.2 and Q.3 were not presented here as this study did not separate the effect of gender and the class status because the survey was anonymous and on-line using leaning management system (LMS) where the responses from different group cannot be separated without additional questions.

Based on the responses to Q.4 as to how the participants liked attending the field trips, overall 61% of the participants chose "5", 26% chose "4", 7% chose "3", 2% chose "2" and, 4% chose "1". The distribution of Q.4 responses is presented in Figure 4. Based on the choice distributions, it is obvious that maximum number of participants (more than 87% chose "4" and "5") highly preferred to attend the field trips during the semester. Although overall participation in spring 2017 was low, more than 90% participants highly preferred attending the field trips, in summer 2017 more than 89% participants highly preferred attending the field trips, and in fall 2017 more than 84% participants highly preferred attending the field trips. This data indicate that field trips in learning environmental engineering seem to be important and well perceived by the students. The weighted average of Likert scale choices is presented in Figure 5. This analysis was performed to understand the students' perception and attitude about the field trips that may have enhanced the learning of environmental engineering. As see in Figure 5, overall weighted average was 4.39. The weighted average for the three semesters varied from 4.30 to 4.42, with the highest score for summer 2017.

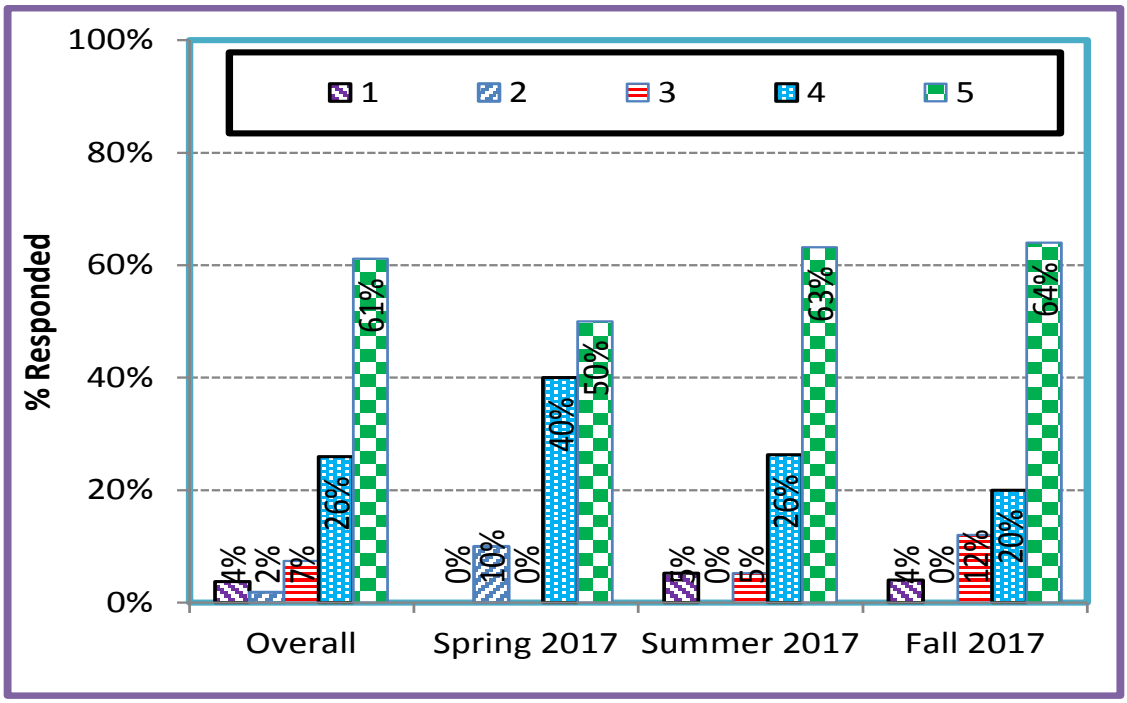

Figure 4: Distributions of choices of the participants about the effects of field trips

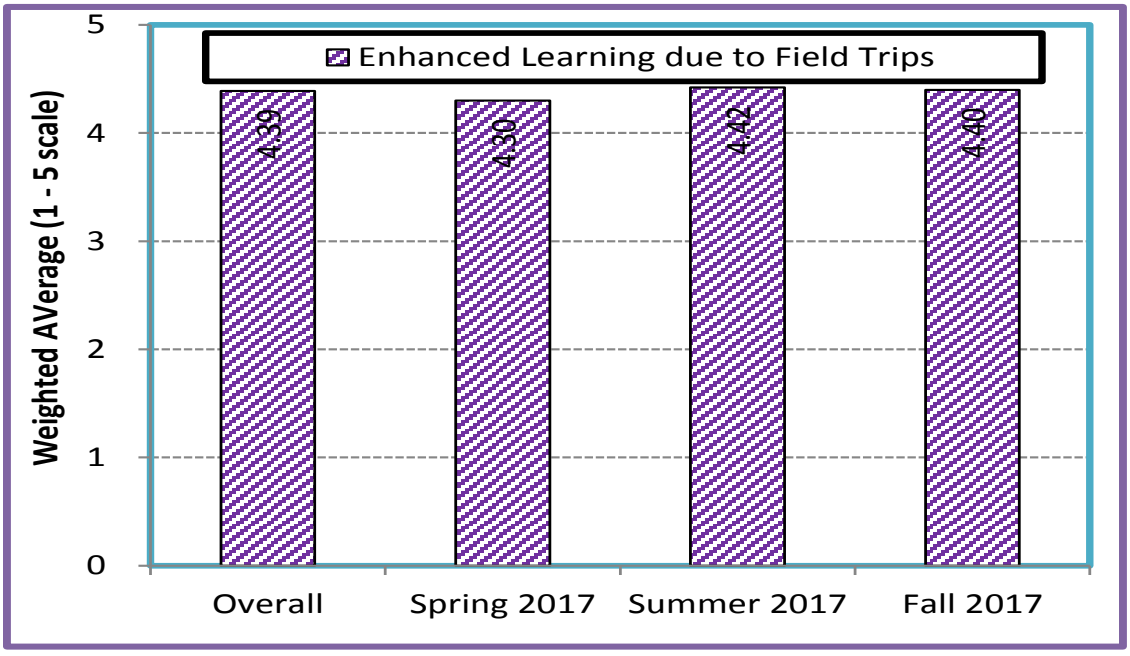

Figure 5: Distributions of weighted average of the choices of the participants about the effects of field trips

As mentioned earlier, in order to assess the students' understanding about the water and wastewater treatment processes, one question was set in the midterm exam to draw a flowchart for a typical WTP and another question was set in the final exam to draw a flowchart for a

typical WWTP. The assessment was done for spring 2017, summer 2017, and fall 2017 and compared with a control section for fall 2016 semester (no field trips). The distribution of average scores on WTP and WWTP flowchart questions is presented in Figure 6. As shown in Figure 6, the average scores for WTP flowchart question were 81% for control (fall 2016), 84% for spring 2017; 86% for summer 2017, and 82% for fall 2017). The average scores for WWTP flowchart question were 76% for control (fall 2016), 70% for spring 2017; 69% for summer 2017, and 76% for fall 2017. It appears that in summer 2017, average score was the highest (86%) for WTP flowchart question and the average scores for all semesters were higher than that of the control semester. However, average scores for WWTP flowchart question were lower than that of control semester except for fall 2017, which was equal. Better scores in the summer semester could be due to the fact that the field trip was valued 10% of the overall grades and the students had paid attention during the trip knowing that there would be questions on the processes in the exams. Based on the scores of the other two semesters, it is obvious that students did not pay attention to the processes and they just participated for the sake of participation. Therefore, it could be concluded that field trips without any incentives could be important and useful to some extent for understanding of the process concept and other engineering involvements. Although the scores are not significantly different, field trips can be made more useful for deep understanding of the processes and other engineering involvements as well as for generating critical thinking in students, if they are implemented with some sort of incentives. In order to improve the deep understanding of the treatment processes and encourage involvements, students could be further alerted and clarify the expectations before the field trips.

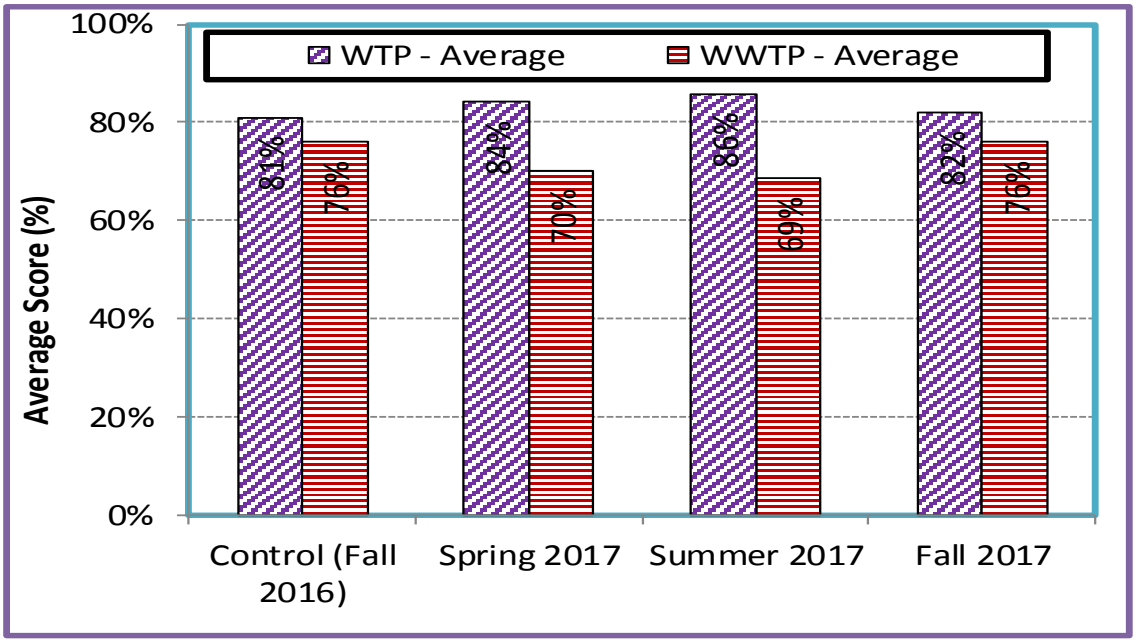

Figure 6: Distributions of average grades for WTP and WWTP flow-charts

The typical comments received in response to Q.5 (Figure 1 - Questionnaire) are quoted below. Most of the participants responded to this question. However, only a few pertinent and relevant comments and one of the similar responses are quoted below.

"The trips have been very informative."

"They are really helpful in getting a full understanding of the water filtration process."

"The field trip was an enjoyable experience. I hope to have more in the future."

"The field trip was interesting and informative. It helps bring the information we learned in class into an experience we can see in person and how it works."

"The water treatment plant trip is very helpful to relate class work with real life examples. VERY HELPFUL."

"I really enjoyed the water treatment plant visit because, I was able to see the actual size of these plants and how the machinery functions as opposed to just seeing a flow chart on paper."

"A solid addition to the course that serves to bolster anything learned in class. Definitely a worthwhile trip."

Summary and Conclusions

In this paper, an effort was made to assess the perceptions and attitudes of students as well as understanding of environmental engineering by the students, which influence the learning environment, through the field trip in environmental engineering. The course, `Introduction to Environmental Engineering', was developed and taught incorporating the field trip in the course curriculum. In this course set up, two field trips were arranged: one in a local water treatment plant after finishing the topic water treatment and drinking water standards and the other in a local wastewater treatment plant after finishing the topic wastewater treatment and disposal. At the end of the semester, an anonymous survey was conducted with five questions to understand the perceptions and attitudes of students that had participated in the field trips. To assess the students' understanding about the water and wastewater treatment processes, one question was set in the midterm exam to draw a flowchart for a typical water treatment plant and another question was set in the final exam to draw a flowchart for a typical wastewater treatment plant. Based on the collected data and analysis, students' perceptions and attitudes about field trip approach appeared to be favorable and acceptable as a learning environment of water and wastewater treatment processes that could be tailored for future environmental engineering courses. Based on the assessment of flowchart questions, field trips had some effect as a learning tool in terms of knowledge retention about water and wastewater treatment processes. However, more data need to be collected and statistically analyzed to affirm this statement.

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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 Assistant Professor 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 five 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. Currently Dr. Karim is an associate professor of civil engineering and assistant department chair of Civil and Construction Engineering Department at Kennesaw State University.