Using Your Campus as a Laboratory: An Adaptable Field Trip on Geomorphology for Engineering Geology

Dr. Kristin M. Sample-Lord P.E., Villanova University

Dr. Kristin Sample-Lord is an assistant professor in the Department of Civil and Environmental Engineering at Villanova University, with expertise in geotechnical and geoenvironmental engineering. Her research focuses on soil barrier systems for protection of human health and the environment and geotechnical aspects of stormwater control measures. Dr. Sample-Lord teaches a number of undergraduate and graduate courses, including Geology for Engineers, Soil Mechanics and Geoenvironmental Processes.

Dr. Virginia Smith, Villanova University
Prof. Patricia Gallagher P.E., Drexel University (Eng. & Eng. Tech.)

Dr. Patricia Gallagher is an Associate Professor in Civil, Architectural and Environmental Engineering at Drexel University. She specializes in geotechnical engineering, geoenvironmental engineering, and sustainability and resilience of infrastructure. She has researched soil improvement for hazard mitigation and contaminant remediation, the use of recycled materials in geotechnical engineering applications, and the use of life cycle assessment to develop metrics assessing the environmental sustainability of geotechnical engineering works. Her current focus is on incorporating life cycle assessment methods into geoenvironmental and geotechnical engineering to provide decision-making tools for the environmental sustainability of infrastructure and remediation projects. She researches and implements evidence-based teaching strategies in engineering education and has extensive experience with recruitment and retention of underrepresented students. Dr. Gallagher also participated in the development of the NSF ADVANCE funded Executive Leadership in Academic Technology and Engineering (ELATE) program at Drexel University. ELATE is a national leadership development program to advance senior women faculty into leadership.

Dr. Andrea L. Welker, Villanova University

Andrea L. Welker, PhD, PE is a Professor in the Civil and Environmental Engineering Department and the Associate Dean for Academic Affairs at Villanova University. Most of Dr. Welker's research is focused on stormwater control measures including monitoring of individual practices as well as the effects of stormwater management on streams. She is currently part of a multi-state, multi-year effort supported by the William Penn Foundation to ensure plentiful, clean water in the Delaware River Watershed. In addition, she is studying the effect of modern-day stormwater management on streams. She is active in the Geo-Institute of the ASCE and is also the Chair of the Civil Engineering Division of ASEE.

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Abstract

Civil engineers at Villanova University are required to take a geology course as part of their undergraduate curriculum. However, engaging and interesting civil engineering students in geology has historically been a challenge. This course provides students with an understanding of geological concepts that will be of use in two later courses, hydraulics and hydrology and soil mechanics. In addition, this course helps to fulfill the math and science ABET requirements. The last third of the course covers geomorphology topics (e.g. hydrologic cycle, landscapes, streams and rivers, floods, groundwater, glaciers, oceans, coasts, and sea level rise). Three years ago the course was converted to a flipped (inverted) format, which motivated the geotechnical and water resources faculty to develop an on-campus geomorphology field trip to better engage students with the material and emphasize the relevance of the course to civil engineering. The geomorphology field trip, which was designed to take 75 minutes, includes eight stops and focuses on anthropogenic and bio-driven morphology. Faculty set the stage for the field trip for 15 minutes, then the class spends 60 minutes exploring the campus. During the field trip, students complete a worksheet and record their observations for each stop. Many aspects of the field trip likely are easily adaptable to other university campuses. The content of the field trip is described in detail, with example photographs of each feature. Results from student surveys regarding students' perception of the field trip in fall 2018 are presented. Based on the surveys, 100% of the students felt that the field trip improved their overall learning experience, and 97% of the students recommended that the field trip continue to be offered in subsequent years. In addition, the results from a final exam question based on the field trip content and from a similar question administered one year after the field trip are included in the discussion of student learning and retention of the geomorphic content.

Introduction and Background

Undergraduate students enrolled in civil and environmental engineering (CEE) programs often are required to take a basic geology course as part of their undergraduate curriculum. At Villanova University, Geology for Engineers (CEE 2805) is a required, three-credit course for all sophomore CEE students. The class meets twice a week for 75 minutes and is taught in two sections with approximately 30 students in each section. This geology course fulfills a science requirement for ABET, and is designed to convey an overview of geosciences relevant to engineering. In particular, geomorphology topics (e.g. hydrologic cycle, landscapes, streams and rivers, floods, groundwater, glaciers, oceans, coasts, and sea level rise) and their relevance to CEE are covered in the last third of the course.

Engaging and maintaining student interest in the geology content had been challenging, as some of the engineering students struggled to appreciate the relevance of basic geology to CEE [1, 2]. The authors were inspired by the reported benefits of a flipped (i.e. inverted) engineering classroom described in the literature for mechanics courses typically taught in engineering undergraduate curriculums [3-10]. At Villanova, other faculty in the civil engineering

department have been successful in implementing these techniques in their mechanics and structural design courses [10, 11]. Other studies on the impacts of the flipped engineering classroom have been reported for software [12, 13], electrical engineering [14], industrial engineering [15], architectural engineering [16], and soil mechanics courses [17]. Based on the support in the literature, the authors decided to overhaul the Geology for Engineers course from a mostly lecture format to a flipped classroom format starting fall 2016. In the new format, basic geology content is delivered outside of the classroom via short recorded lectures or free geoscience videos. The class time is primarily devoted to engineering applications of geology and active learning. Details of the flipped format used in this course can be found in [1].

To strengthen students' understanding of the relevance of geomorphologic processes to engineering, an on-campus field trip was designed for one of the 75-minute class periods, occurring in the 10th week of the semester. Geotechnical and water resource engineering faculty collaborated to leverage their combined expertise in the development and delivery of the field trip. The primary goal of adding the on-campus field trip to the course was to expose students to "real-world" examples of the concepts they had been learning about and demonstrate how geomorphology affects design, maintenance, and resilience of infrastructure and the university campus around them.

The on-campus field trip has been offered three times to date (fall 2016, fall 2017, fall 2018) and has consistently received positive feedback from the students. The results of student surveys, as well as data from final exams and an in-class question presented to the students one year after the trip, suggest that the field trip is an effective teaching tool. These results, as well as the details of the field trip, are described herein. Many aspects of the field trip likely are easily adaptable to other university campuses, and photographs are included of the major features visited on the trip. On campus field trips are effective and efficient because they can usually be performed within the time frame allotted for class and they avoid the logistical and financial issues associated with off-campus trips.

The On-Campus Field Trip

At the beginning of class on the day of the field trip, the faculty foster the students' interest with an approximately 15-minute long PowerPoint presentation that provides them with real-world examples of how geomorphology impacts infrastructure, the environment, and even political boundaries. The students then depart on an hour-long trip around campus to see examples of geomorphology concepts that have been discussed in class. The trip typically is led by one or two faculty members. During the trip, the students fill out a handout, which consists of an empty table for them to fill in descriptions of each of the eight stops, and a campus map to mark the locations of each stop. Each stop and the geomorphic concept that is demonstrated is described subsequently. Several of the features likely can be found on most other university campuses.

Stop 1. Alluvial Transport: Morphology of a rain garden

This site features two examples of green infrastructure for stormwater control. The rain gardens collect stormwater and allow infiltration into the soil to reduce flooding, capture pollutants, and recharge the groundwater. However, over time sediment, trash, and debris move into and around

the gardens impacting their performance. In the photo shown in Fig. 1, leaves blown into the rain garden impede infiltration.

Stop 2. Fluvial Geomorphology: Washout due to a rain gutter

A rain gutter draining a large roof discharges into soil and runs downslope to a road. As the flow runs over the surface some sediment is picked up and moved. At the outlet (where the flow is strongest) the largest particles are left behind. Over distance, the flow loses its transport capacity due to dissipation of shear stress. As a result, the deposition is graded to reflect the ability of the flow to transport grains of differing sizes (Fig. 1).

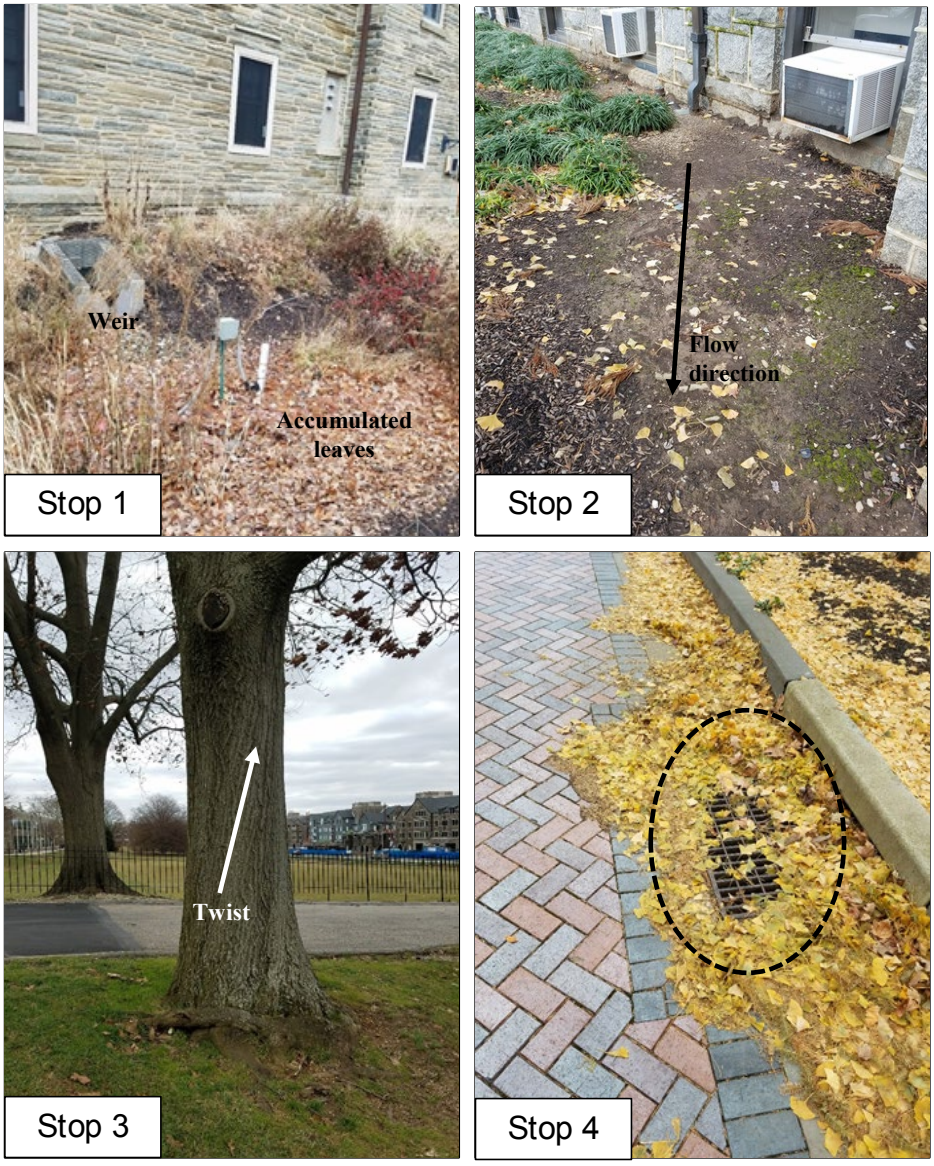

Figure 1. Stops 1 through 4 of the field trip.

Stop 3. Biological Geomorphology: Tree throw
Gentle hillslope processes allow gravity to pull the hillslope down over time. This coupled with erosion around the tree causes the tree to twist as it grows (Fig. 1). Eventually, the tree may even twist itself out of the ground and fall over, resulting in tree throw. This can often be seen in older trees planted on hillslopes.

Stop 4. Alluvial Sediment Transport and Morphology: Stormwater sediment and debris deposition
Storm drains play an important role in civil infrastructure. Maintaining these features is critical to their success, but maintenance is expensive. Sediment, trash, and debris are transported through wind and water into the drains (Fig. 1). Cities spend millions of dollars annually to clean out storm drains. In the Philadelphia area these are cleaned approximately once a month and the debris is taken to a landfill. It is important to note that much of the sediment would otherwise make its way to the coast where it would replenish coastal wetlands and beaches.

Stop 5. Fluvial Geomorphology: Green infrastructure treatment train acts like a river
Green infrastructure is an increasingly common form of stormwater control. Many of these infrastructure features function similar to river channels. The example shown here is a stormwater treatment train (Fig. 2) which controls stormwater from a parking garage. This feature is outfitted with real time controls that circulate water back to the top of the swale after a rain event has ended. The water passes through a series of weirs as it travels from the top of the feature to the bottom. Points of erosion and deposition can clearly be seen, indicating fluvial geomorphic change. These changes represent the shear stress of the flow.

Stop 6. Hillslope Geomorphology: Manhole cover gets covered
Gravity is always working on everything on Earth, including hillslopes. Over time hillslopes drift downslope in response to a myriad of mechanisms driven by gravity. These mechanisms include sliding, slumping, and runoff/alluvial erosion. In this example, a manhole is being covered up by the topsoil of a hillslope (Fig. 2). Over time the soil, and even grass, is pulled downslope by gravity, altering the landscape and covering up the manhole cover.

Stop 7. Biological Geomorphology: Roots break retaining wall
Over time plants and animals alter the landscape by growing and burrowing. Tree roots are powerful and are able to crack rocks, as well as foundations and retaining walls. In this example students are shown tree roots breaking through a retaining wall (Fig. 2). Years ago the roots were not an issue, but as the tree grows the roots put increased pressure on the wall.

Stop 8. Impacts on the Morphology of a Drainage Basin: Sediment control measures
Construction generates sediment due to earth disturbance. The sediment generated has the potential to enter the stormwater system and enter local streams and rivers, resulting in environmental impacts. To mitigate this watershed impact, sediment collection management is mandated through most state and/or county environmental management agencies. At this stop, students are shown examples of sediment collection management at a construction site on campus. The image in Fig. 2 show bags filled with mulch to allow water to flow through.

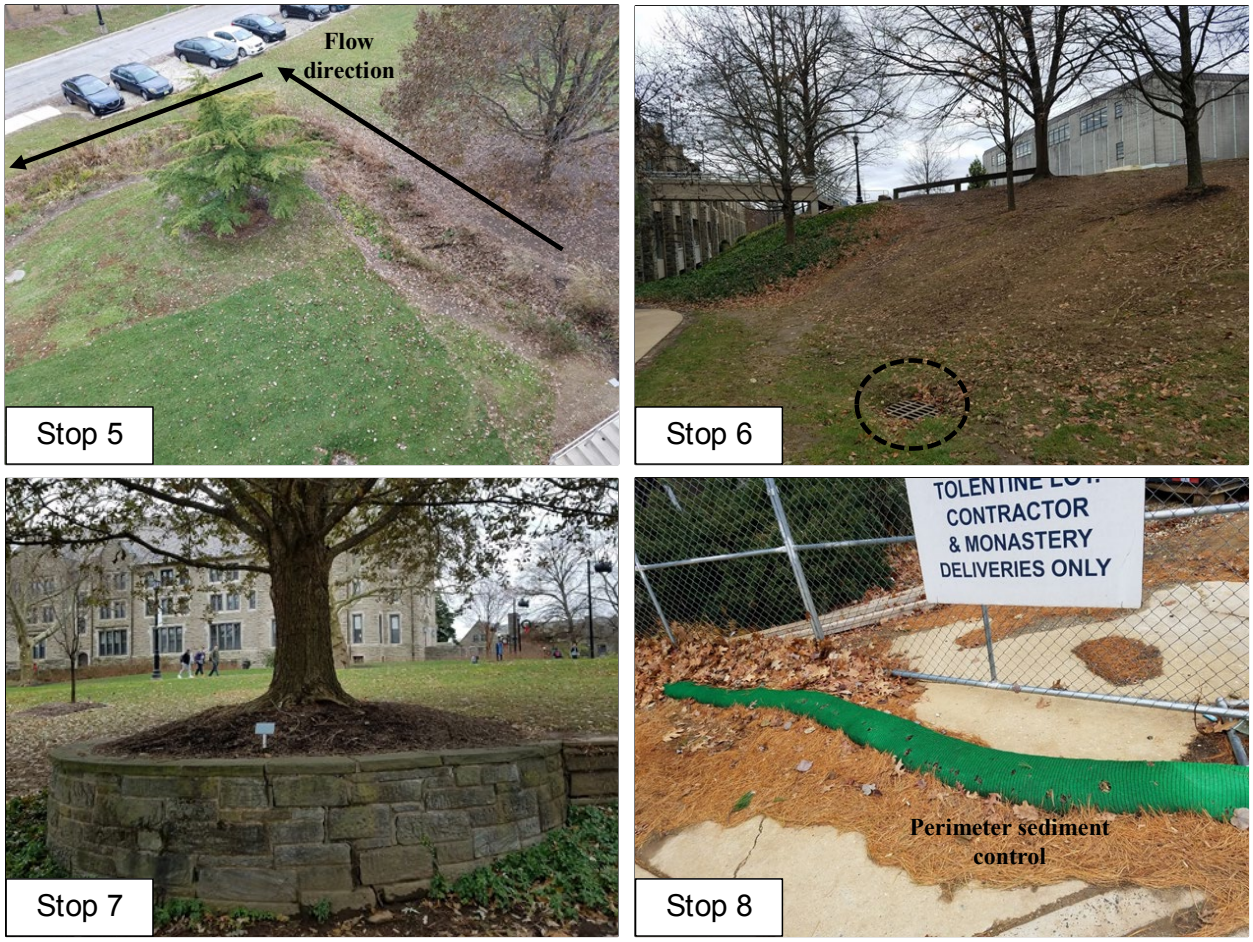

Figure 2. Stops 5 through 8 of the field trip.

Student Feedback

To collect student feedback regarding the on-campus field trip, an anonymous survey was administered after the field trip in fall 2018. The purpose of the survey was to ask students about their learning experience and their perceived effectiveness of the on-campus field trip for demonstrating geomorphology concepts. The survey questions are provided in Table 1. The answer choices were: strongly disagree (1), mildly disagree (2), mildly agree (3), and strongly agree (4). A total of 27 and 28 students completed the surveys, representing 100 % and 93 % of the enrollment in Sections 1 and 2, respectively.

Table 1. Summary of survey questions and results collected after on-campus field trip in fall 2018.

Survey Question	**Average Scores (out of max score of 4)**		**% Responded Mildly or Strongly *Agree***		
	Section 1	Section 2	Section 1	Section 2	Average
1. I understood what the field trip leader was explaining and demonstrating on the tour.	3.81	3.93	100	100	100
2. The field trip occurred at an appropriate time during the semester (i.e. enough topics had been covered for me to apply the knowledge on the trip).	3.67	3.93	96	100	98
3. For this topic, I preferred this learning format over a classical in-class lecture.	3.44	3.42	93	100	97
4. I feel that the field trip improved my understanding of basic geology concepts.	3.44	3.76	96	100	98
5. I feel that the field trip improved my ability to apply basic geology knowledge in a real-world context.	3.78	3.93	100	100	100
6. I feel that the field trip improved my understanding of the relevance of geology to civil engineering.	3.81	3.82	96	100	98
7. The field trip increased my interest in how rock, soil, water, and climate play roles in civil engineering infrastructure.	3.52	3.50	96	96	96
8. I feel that the on-campus field trip improved my overall learning experience.	3.67	3.96	100	100	100
9. I would recommend offering the field trip in future course offerings.	3.63	3.93	93	100	97
Total Number of Survey Responses Received	27	28	27	28	55

The students had positive responses regarding the delivery and format of the field trip (questions 1 – 3) (Table 1). More importantly, ≥ 98% of the students felt that the field trip improved their understanding of basic geology concepts, ability to apply the knowledge in a real-world context, and understanding of the relevance of geology to CEE. On average, 96% of the students indicated an increased interest in the interaction between civil infrastructure and soil, water, and climate. These results are in agreement with anecdotal observations from other faculty regarding an increase in student interest over the last two years in geotechnical engineering and water resources engineering in subsequent semesters. All of the students felt that the field trip improved their overall learning experience, and overwhelmingly (97%) recommended the trip continue to be included in subsequent course offerings.

Performance on Final Exam Question

On the final exam in fall 2018, the students were given a question to determine their retention of the information covered one month prior on the field trip. In the exam question, photographs of Stops 4, 6, and 7 were shown (very similar to the photos in Figs. 1 and 2). For each photo,

students were asked to describe: (1) the geomorphic concepts from class being demonstrated and (2) how the concepts demonstrated in the pictures were relevant to CEE. The question was worth 3 points total, with 0.5 points earned for (1) and 0.5 points earned for (2), for each of the three pictures. For the 56 students who took the final exam in fall 2018, the average score for this exam question was 2.71 out of 3.0 (90.4%). This high average score suggests that the students remembered many of the concepts and understood the relevance of the content of the field trip. The most common mistake was that the students did not mention the biological impacts of the tree roots on the wall in the photograph of Stop 7.

Retention of Knowledge

To determine if students retained what they had learned during the field trip, students that had completed the geology course in fall 2017 were given the previously described exam question one year later in another course. The question was posed in the junior-level Hydraulics and Hydrology (H & H) course in spring 2018 to assess the knowledge retention of those completing the field trip in fall 2017. The question was distributed during an H & H lab section during the second week of class. The students were not given any specific review of the geomorphology field trip prior to distributing the question. During class, students were given approximately 5-10 minutes to fill in their answers, and then the sheets were collected. The question was not part of their grade, because its purpose was to gauge retention of the material. The question was evaluated using the same rubric for the fall 2018 final exam question, as described previously. A total of 50 students completed the question and the average score was 2.46 out of 3.0 (82.0%). The authors were pleasantly surprised by this level of retention by the students, particularly as this cohort had taken the field trip in fall 2017 and did not have this question on their fall 2017 final exam.

Conclusions

Geotechnical and water resource engineering faculty at Villanova University collaborated to develop an on-campus field trip focused on geomorphology for use in an undergraduate engineering geology course. The purpose of the field trip is to strengthen students' understanding of the relevance of geomorphologic processes to CEE, by showing them "real-world" examples of how geomorphology affects design, maintenance, and resilience of the infrastructure around them. The on-campus field trip takes 75 minutes total, and includes eight stops. Pictures and descriptions of each stop were provided herein. The trip has been offered three times to date (fall 2016, fall 2017, fall 2018). Based on the results of student surveys, as well as data from final exams and an in-class question presented to the students one year after the trip, the field trip is an enjoyable learning experience for the students and is an effective teaching tool. From the student surveys, more than 98% of the students felt the field trip improved their understanding of geomorphology and the relevance to CEE. In addition, 96% of the students indicated an increased interest in the interaction between civil infrastructure and soil, water, and climate after taking the field trip. Final exam scores on content covered in the field trip were high (90.4%), indicating that the trip was an effective teaching tool. Students questioned on the material one year after taking the field trip scored an average of 82.0% on geomorphology concepts covered on the field trip, demonstrating retention of the knowledge. Many aspects of this field trip likely

are easily adaptable to other university campuses, and may provide an effective and efficient teaching approach for faculty who prefer to avoid the logistics of an off-campus trip.

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