Flipping the Infrastructure Classroom

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This paper and its companion poster are the result of a recent (September 1, 2013) funding award from the National Science Foundation. The outcomes of the proposed work are:

- Establish and sustain the Center for Infrastructure Transformation and Education (CIT-E) as the source for infrastructure education materials that are continuously improved by a vibrant community of practice
- Develop educational expertise in infrastructure topics and in pedagogy in faculty at six collaborating institutions
- Deliver, assess, and institutionalize infrastructure-themed courses or modules for Civil and Environmental Engineering (CEE) majors and other majors at collaborating institutions
- Enhance the ability of CEE students to view components and systems designed in CEE subdisciplines as integral parts of a larger system (i.e. the infrastructure)
- Enhance the ability of CEE students to view infrastructure challenges from a societal perspective, rather than solely from a technical perspective

The CIT-E currently consists of more than ten civil and environmental engineering programs seeking to improve the coverage of infrastructure content in their curricula. Materials created at the University of Wisconsin-Platteville and the United States Military Academy have been made available to partner universities and have been used to varying extents in the infrastructure courses currently being offered or being developed at the following universities:

- Portland State University
- Virginia Military Academy
- Rowan University
- University of Nevada-Reno
- New Mexico Tech
- Norwich University
- University of Alabama-Tuscaloosa
- Arizona State University
- University of Toledo
- University of Nebraska-Lincoln

In June 2014, the first Infrastructure Education workshop was held in Milwaukee, WI. At this workshop, participants were provided with model materials and were assisted in beginning to design their courses. One day of the three-day workshop was devoted to "flipping" the classroom, wherein the activities traditionally completed in class (e.g. listening to lectures) are completed out of class, and the activities traditionally completed out of class (e.g. working problems) are completed in class. Participants were all given the opportunity to create screencasts suitable for the flipped classroom, and these screencasts were peer-reviewed.

Flipping is relatively easily adapted to courses for which homework is computational in nature; this type of homework can readily be converted into in-class activities. For example, consider the fluid mechanics topic of force on a planar surface. In the conventional delivery method, students would be given a lecture

on the topic and then complete take-home computation-based problems. In the flipped classroom, the instructor would prepare relatively brief video recordings of lectures and these would be made available to students to watch before class. Students, most likely working in small groups, would work on the homework problems in class. To prepare for such a class, the instructor would most likely review the problems before the class period, and depending on his or her experience level, might work out the problems ahead of time for practice. For this type of problem, the questions students will raise are relatively predictable. Student correctness can be judged easily using an answer key.

However, an introductory infrastructure course provides some challenges as compared to this fluid mechanics example. In an infrastructure course, homework is not computational, is typically open-ended, and may be field-based. In many instances, the questions seek to address the higher levels of Bloom's Taxonomy, requiring students to synthesize. Consider a problem asking students to describe the infrastructure needed to support a new mining venture in a developing country. This is a far richer question than the computational type fluid mechanics problem described above. In contrast, the instructor preparation will be much more extensive; he or she will need to be at least semi-expert in technical areas (e.g. mining, power distribution, transportation) and non-technical areas (e.g. social, political, economic areas). Moreover, the types of questions that students will ask are much less predictable and more complex. And no answer key exists.

Discussion of broad topics such as a new mining venture are not necessarily *daily* in-class activities. On a more routine basis, in-class discussions can be utilized to expand student understanding and appreciation of more focused topics such as environmental justice, professional licensure, or even technical aspects such as the importance of drainage in retaining wall design.

As a result of the Summer 2014 workshop, the CIT-E community had a deeper understanding of flipping. We understood that flipping is not simply a matter of recording some screencasts for students to watch out of class. Rather, the design of the flipped classroom exercises must be *intentional*. The Second Annual Infrastructure Education Workshop is planned in May 2015 to answer the following questions, and the answers will be reported on the companion poster to this paper.

- **What material in the current course(s) can readily be adapted to out-of-class screencasts?** The answer to this question will provide an estimate of how much class time is now freed up for active learning exercises.
- **What are the characteristics of an effective in-class question for the flipped infrastructure course?** The question ought to be open-ended and deep enough for students to see the benefit of addressing the problem as a team, as compared to answering it individually. It should challenge students without causing undue frustration.
- **What other types of active learning activities can be used in class?** An introductory infrastructure course lends itself to in-class discussions of "difficult problems," but this type of active learning activity is not the only type we will explore. Additional activities include the "think-pair-share," jigsaw puzzle, and case studies.
- **What information will students need to acquire outside of class prior to the in-class exercise?** As for all flipped classroom out-of-class content, the information will need to support the learning outcomes and add sufficient value such that students will be at a disadvantage if they do not complete it.

- **How does an instructor guide wide-ranging and nebulous in-class conversations?** Not every faculty member has the skills or disposition to guide such an in-class activity. We hope to identify the needed skills, knowledge, and attitudes for faculty members to lead effective classroom discussions and help faculty members acquire them. One outcome of the 2015 workshop will be a model lecture illustrating how to effectively guide the in-class activities.
- **What knowledge does the instructor need to acquire prior to the in-class exercise?** Given the breadth of the infrastructure field, few faculty members teaching an introductory infrastructure course for the first time will have all the necessary knowledge.
- **Where does an instructor obtain the needed knowledge outside of his or her area(s) of expertise?** The CIT-E website will eventually contain background information for instructors and students, and will create a library of screencasts to be used for out-of-class student learning.
- **What questions will students have for a given activity?** Predicting these questions is much more difficult for the types of activities envisioned for the flipped infrastructure classroom; however, it is this aspect that potentially makes teaching the flipped infrastructure class an exciting and ever-changing adventure.
- **How is the in-class exercise to be assessed?** Although an answer key will not be available for many of the envisioned activities, student learning will still need to be assessed, and will need some expert closure on their in-class activities.
- **How can we help students see the value of the in-class activities?** Hopefully, the value of the in-class activities will be obvious to students. However, some students, accustomed to writing out several pages of notes in a lecture period, may feel that they have not learned anything as a result of "sitting around and talking." "Focused listing" and "note checking" are two active learning summarizing techniques that will be employed following an in-class discussion or other active learning activity to ensure that students leave the classroom with an accurate and complete summary of how the class met the learning outcomes.

Assessment of the entire project objectives, as well as the workshop outcomes, will be assessed in multiple ways. Faculty outcomes will be assessed through implementation surveys and interviews. Student outcomes are being assessed through an "infrastructure views" survey and a concept map assessment. Results from the workshop will be published in future ASEE Annual Conference proceedings as well as on the CIT-E website.

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