



Positioning Students to Understand Urban Sustainability Strategies through Vertical Integration

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Sustainability has been proven to be a significant need for the civil and construction engineering and management (CCEM) industries. The concept of sustainability, however, is not commonly taught in the undergraduate curriculum; it is generally covered and taught in graduate-level courses. Though undergraduate students may have an interest in sustainability, their exposure to it comes later in their educational curriculum. In this Transforming Undergraduate Education in STEM (TUES) project, the researchers develop a problem-based learning framework that (1) introduces sustainability earlier in the undergraduate curriculum, and (2) provides an opportunity for vertical integration across courses within CCEM curriculum. The goal of introducing sustainability concepts is two-fold: to enhance undergraduate students' interest in and understanding of sustainability by engaging them in real-world sustainability projects; and to provide students with necessary knowledge for advancing a career in sustainability within CCEM. The vertically-integrated problem-based learning (PBL) framework developed in the course of this TUES project provides undergraduate students with both knowledge and tools needed to address urban sustainability issues in their future careers, whether in industry or academe. This framework is replicable and can thus be deployed across universities as part of the CCEM curriculum.

The PBL framework is developed and implemented at Arizona State University between a lower-division construction management course, *Construction Materials, Methods and Equipment* (CON252) and an upper-division/graduate cross-disciplinary course between civil engineering course, sustainability, and planning, *Urban Infrastructure Anatomy and Sustainable Development* (CEE 598). CON252 focuses on the building design and construction process, ranging from excavation to material choice to various building systems. CEE 598 focuses on infrastructure systems from the technical and environmental perspectives and examines the interdependences between these infrastructures.

This poster summarizes the progress and accomplishments of the project during years one and two. We review the development of final project assignments for the two courses involved in the project and discuss how these evolved from year one to year two. We also present preliminary feedback from students and instructors about the PBL framework.

Summary of Pilot Implementation of the Vertically Integrated PBL Framework

The vertically-integrated PBL framework was piloted in the Spring 2014 semester, and this implementation provided lessons learned that contributed to further refining and restructuring the framework. In the pilot implementation, students in the CON and CEE courses connected through one student group in CEE 486/598 (Figure 1). Students from the lower-division course performed a quantity takeoff for this singular group, and did not interact with the entire CEE 486/598 student body. Moreover, the integrative aspect was not stressed between the two courses as strongly as it should have been, as the idea of vertical integration did not resonate with student groups in either of the courses throughout the semester.

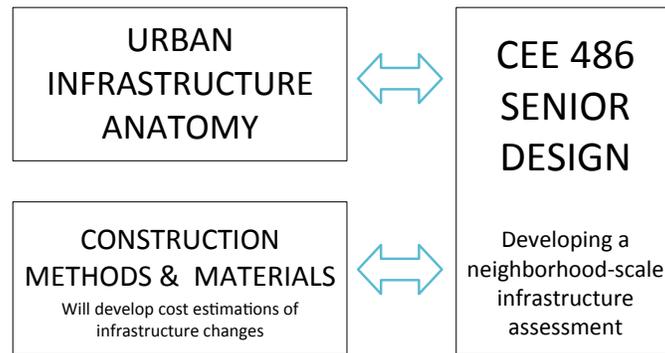


Figure 1: Vertical Integration Scheme for Pilot Implementation (Spring 2014)

Revisions Based on Feedback from Pilot Implementation

Feedback from the pilot implementation suggested that students from both courses did not really feel any connection to students in the other course. Thus, the following improvements were made to the vertically-integrated PBL framework for the Spring 2015 implementation:

- Instructors added in more opportunities and requirements for student interaction, including:
 - A formal kickoff meeting where student representatives from CON 252 met with all students from CEE/SOS 598.
 - An implemented ‘Request for Information’ system that allowed for both professional and formal communication, and collaboration between courses.
 - The invitation for CEE/SOS 598 students to serve as reviewers for CON 252 final project presentations.
- Instructors adjusted project assignments in both courses to better align with one another.
 - The final project for CON 252 focuses on building a prototype for different building types (commercial office space, commercial retail space, single-family residential homes, multi-family residential homes, and other building types).
 - The class project for CEE/SOS 598 focuses on a more macro scale, and takes into account all building types focused on in CON 252. There are four groups in CEE/SOS 598: Buildings, Transportation, Environment, and Social/ Institutions. The final project groups for CON 252 and how they overlay with CEE/SOS 598 is shown in Figure 2.

	Commercial Retail Space	Commercial Office Space	Single-Family Residential	Multi-Family Residential	Other Building Types
New Construction	Team 1	Team 2	Team 3	Team 4	Team 5
	Team 6	Team 7	Team 8	Team 9	Team 10
Adaptive Reuse	Team 11	Team 12	Team 13	Team 14	Team 15
	Team 16	Team 17	Team 18	Team 19	Team 20

Figure 2: Spring 2015 CON 252 Final Project Groups. The five teams highlighted in **blue** will work along side the Buildings group in CEE/SOS 598, the five teams highlighted in **red** will work alongside the Transportation group in CEE/SOS 598, the five teams highlighted in **green** will work alongside the Environment group in CEE/SOS 598, and the five teams highlighted in **orange** will work alongside the Social/Institutions group in CEE/SOS 598.

Second Implementation: Spring 2015

In the second implementation, overall project themes better reflect one another to promote vertical integration between the two courses. The vertical integration process is shown in Figure 3 below.

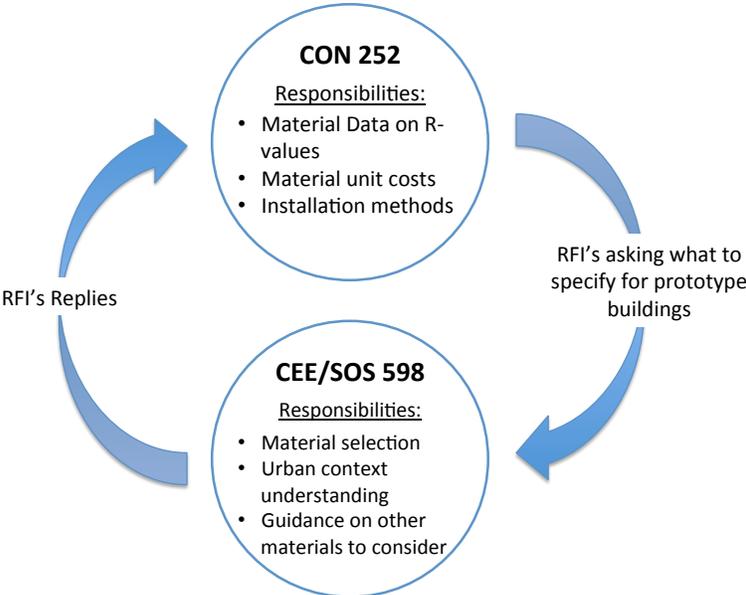


Figure 3: Vertical integration Scheme for Second Implementation (Spring 2015)

Results suggest more cohesive projects bring about greater opportunities to integrate the two courses through assignments and tasks. The idea of vertical integration is a focus throughout the semester, as students from each course will visit the other to introduce their projects and task needs. Consistent communication between the two courses encourages involvement in each other's projects, and further promotes vertical integration between the lower-division and upper-division undergraduate course.

Evaluation

A more meaningfully engaged evaluator team is incorporated into the second implementation to further improve class evaluations for both CON 252 and CEE/SOS 598. The evaluator team developed pre and post-surveys along with a mid-semester survey that assess learning and collaboration throughout the semester. These surveys allow for the vertically-integrated PBL method to be assessed and improved upon in the future.

Publications Resulting from this Work

Significant accomplishments have been achieved to date that further promote the idea of vertically-integrated PBL. We disseminate our accomplishments in the following publications:

- Chester, M., Parrish, K., & Mann, C. (2015). *Positioning Students to Understand Urban Sustainability Strategies through Vertical Integration*. Proceedings of Engineering Sustainability 2015. Pittsburgh, PA. April 8-9. 4pp.
- Ghosh, A., & Parrish, K. (2013). From BIM to Collaboration: A Proposed Integrated Construction Curriculum. Paper presented at the ASEE Annual Conference & Exposition, Atlanta, GA. 10 pp.
- Ghosh, A., Parrish, K., and Chasey, A. (2014). "Implementing a Vertically Integrated BIM Curriculum in an Undergraduate Construction Management Program." *International Journal of Construction Education and Research*, In press. DOI: 10.1080/15578771.

Acknowledgments

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