Promoting Transdisciplinary Thinking, Sustainable Design, and Community Engagement in STEM Education

Course

CEE/UAP 5984—*Collaborative (Re)development* (new course)

Enrollment

Current: New course (not applicable)

Anticipated:
Spring semester studio course: 24 graduate students
Online course** (Summer I/II; Wintermester): 30 graduate/undergraduate per semester

***We anticipate developing an online spin-off version of the course content for use in Summer I/II and/or Wintermester and for dissemination to professional development organizations. See below*

Investigators:

Tripp Shealy
tshealy@vt.edu
Civil and Environmental Engineering

Thomas Skuzinski
skuzinsk@vt.edu
School of Public and International Affairs (Urban Affairs and Planning program)

Work to be done

We will be developing content for, delivering, and disseminating educational STEM research from a new experiential learning course targeted at graduate students in civil and environmental engineering, urban affairs and planning, real estate development, and related fields. The grant will support:

- novel content creation and organization in summer and fall 2018 (lectures, case study development, online video modules, and a suite of learning measurement tools around transdisciplinary learning, sustainability science, and community engagement);
- course delivery will be in spring 2019 and 2020 (we will use active learning pedagogy, take advantage of both real world and virtual site visits, and expand access by making the content available online through a creative commons license);
- evaluation and course revision in summer 2019 and 2020 based on analysis of educational data collected during the course (revision of case studies, readings, lectures, and technologies) ; and
- dissemination and outreach in fall 2019 (conference travel, presentations to professional development organizations, and manuscript preparation).

Background

Engineering students enter careers that require their engagement in complex decisions with professionals from diverse disciplinary backgrounds and members of the public. This is especially true for those who make decisions about infrastructure systems (e.g. drinking water, roadways, and land development) that have both engineering and policy implications. Engineering decisions about infrastructure must not only be functional but should also enhance community quality of life, align with the public interest, and spur future economic development.

The current engineering curriculum prepares students best for independent work or group work with fellow engineers. The standard curriculum at VT, for example, requires no interdisciplinary courses with students studying planning and policy (who are responsible for future codes and zoning requirements that engineers must follow and use in their careers) and developers (who will likely contract engineers for site development and redevelopment). Students lack consistent access to meaningful opportunities to do transdisciplinary, collaborative, participatory work that can promote sustainable, community-driven development. Such knowledge and experience could afford students in engineering and other STEM fields a competitive advantage on the job market, and—due to its embeddedness in a course at VT—would be more broadly accessible than a similar non-curricular opportunity.

We propose developing a course titled "*Collaborative Redevelopment"* to directly address this gap in education. The experiential learning studio course, offered every spring, will draw graduate students from civil and environmental engineering, planning, real estate development, building construction and additional allied fields. Students will apply for admission to the course to ensure balanced enrollment and targeting of traditionally underrepresented groups, allowing for the creation of several multi-disciplinary teams. They will work throughout the semester on three primary tasks oriented around a real-world redevelopment opportunity: site analysis, sustainable redevelopment site design, and community engagement through charrette planning and facilitation. Engineering and STEM students will be evaluated for positive change in their understanding of:

(1) the perspectives of actors in other professions involved in redevelopment (transdisciplinary thinking),
(2) the meaning of sustainable redevelopment, in contrast to more traditional models of redevelopment and development (sustainability), and
(3) innovative methods through technology and industry best practices for including the public as a collaborative stakeholders (community engagement).

Students in planning and real estate will be evaluated as well, and—though we focus on engineering students in this grant application—we would also expect to see improvements in these students' ability to think in a truly collaborative way that crosses disciplinary boundaries and the boundary that often exists between technical experts and the public. The assignments and exams of *Collaborative Redevelopment* will function, in part and consistent with the goal of the 4-VA Course Redevelopment Grant, as data collection instruments that allow us to treat specific course content as an intervention with pre-/post- measurement of student learning. Data-driven pedagogy is essential for concepts such as transdisciplinary thinking, sustainability, and community engagement, which are frequently adopted as educational goals but without clear measurement of pedagogical effectiveness (Allen et al., 2009; Allenby, 2011; Bielenfeldt, 2013). The findings drawn from data analysis will iteratively inform redesign of specific course content during the semester and in the summer and fall between course deliveries.

Over multiple course deliveries, our data will contribute to our knowledge of best practices in experiential learning for transdisciplinary, collaborative, engaged courses targeted at STEM students.

Methodology

Research questions

The *Collaborative Redevelopment* course will allow us to investigate three research questions that align with the three dimensions along which we hope to nudge STEM students' ability to think in systems and across traditional disciplinary silos:

(1) Transdisciplinary Thinking: How do experiential learning and participation in multi-disciplinary teams improve engineering students' ability to articulate diverse disciplinary perspectives and ability to empathize from another's point of view?
(2) Sustainable Design: How does case-based and experiential learning enhance critical engineering agency (i.e. empowerment and identity when they see an opportunity to make change in their world) to address grand challenges for sustainability (e.g. poverty, opportunities for future generations, drinking water, renewable energy) in their careers?
(3) Community Engagement: What innovative methods and technological strategies do students develop to gain feedback about their design from community groups? How do students' engineering solutions change through the community engagement process?

Variables

Table 1. Variables operationalization

Variable type	Transdisciplinary Thinking (T)	Sustainable Design	Community Engagement
Outcome	*Knowledge of:* DECISION-NETWORK (DN): the positions and roles of developers and land use planners and other key decision-makers in the redevelopment system STAKEHOLDERS (S): the other public and private actors in the redevelopment system INTERESTS (I): the motivations and goals of actors in the redevelopment system (decision-makers and stakeholders)	*Knowledge of costs/benefits to:* ENVIRONMENT (EN): consideration of effects on air and water quality, habitat, agricultural lands and open space ECONOMY (EC): public / private fiscal and economic effects COMMUNITY (C): effects on public health, housing, neighborhood, public space, historic preservation	*Knowledge of:* Methods (M): recognize tools, techniques, and management of the charrette systems Facilitation (F): ability to design and collect feedback from community members using innovative technologies Communication (C): effectively exchange information across disciplines and team members
Intervention	*Completion of / Rubric score on:* Developer module Planner module Case study discussion of decision-network, stakeholders, and interests.	*Completion of / Rubric score on:* Sustainability modules Comparative case studies and drafting of, e.g., envt'l impact statements, stormwater mgmt. plans, fiscal impact analysis, housing market analysis	*Completion of / Rubric score on:* Flipped classroom modules about the charrette process Role playing pedagogy to practice charrette facilitation Experiential learning through project-based pedagogy
Controls	Demographics (age, gender, household income, etc.) Curricular exposure (undergraduate and graduate courses) Non-curricular experience (paid and unpaid work) Attendance and participation in *Collaborative Redevelopment*		

Hypotheses

Table 2. Hypotheses and data collection

Dimension	Knowledge component	Hypothesis (all *interventions* are in Table 1)	Data collection instrument (pre-post design)*	Target
Transdisciplinary Thinking	DECISION-NETWORK (DN)	*Satisfactory completion of interventions will be associated with improvements in completeness and accuracy of nodes and relationships in system maps.*	**Time 0** (baseline): Week 1 System map **Time 1** (delta): Week 8 System map	10 point avg. increases,** 0-100 scale, completeness and accuracy scores
	STAKEHOLDERS (S)			
	INTERESTS (I)	*Satisfactory completion of interventions will be associated with improvements in identification of actor biases and motivations in mock negotiation exercise, quiz, and case study reflection essay.*	**Time 0** (baseline): Week 1 Negotiation role play; Quiz; Case study reflection essay **Time 1, 2** (delta): Weeks 5, 10 Negotiation role play; Quiz; Case study reflection essay	
Sustainable Design	ENVIRONMENT (EN)	*Satisfactory completion of interventions will be associated with improvements in correct analysis of environmental impacts and description of alternative redevelopment options.*	**Time 0** (baseline): Week 2 Completion of environmental assessment worksheet **Time 1, 2** (delta): Weeks 6, 11 Completion of environmental assessment worksheet	12 point avg. increases, 0-100 scale, impact evaluation scores
	ECONOMY (EC)	*Satisfactory completion of interventions will be associated with improvements in correct analysis of economic impacts and description of alternative redevelopment options.*	**Time 0** (baseline): Week 2 Completion of fiscal impact worksheet; site plan module C **Time 1, 2** (delta): Weeks 6, 11 Completion of fiscal impact worksheet; site plan module C	
	COMMUNITY (C)	*Satisfactory completion of interventions will be associated with improvements in correct analysis of community impacts and description of alternative redevelopment options.*	**Time 0** (baseline): Week 2 Completion of social worksheet **Time 1, 2** (delta): Weeks 6, 11 Completion of housing inventory; site amenities analysis	

Community Engagement	Methods (M)	Students are able to recall the charrette process and able to develop an appropriate schedule, primary stakeholder list, and budget to conduct a charrette.	**Time 0** (baseline): Week 4 In - class assessment prior to module **Time 1** (delta): Week 5 Homework assessment following modules	12 point avg. increases, 0-100 scale, impact evaluation scores
	Facilitation (F)	Students can manage others during a mock charrette facilitation and collect feedback using primitive techniques (e.g. with sticky notes) and advanced techniques (e.g. virtual reality and online voting systems)	**Time 1** Week 5 In - class role playing module post self-reflection assessment and teacher observation/evaluation **Time 2** (delta): Week 14 Final project assessment self-reflection and teacher observation/evaluation	
	Communication (C)	Students peer-review surveys show high levels of collaboration across multi-disciplinary teams	**Time 0** (baseline): Week 5 Self-reflection after initial meeting with project members **Time 1** (delta): Week 6 Organizational structure of team and communication plan	
*: All pre-/post- measures will be taken under the same time constraints and in the classroom setting during meeting times to control for evaluation conditions. **: Rubrics will be used to ensure that objectivity is maintained as much as possible in evaluation of change from baseline to prevent bias.				

Anticipated outcomes

Some of our outcomes will be realized through development and delivery of the *Collaborative Redevelopment course*:

- Meeting course learning objectives through iterative use of collected data.
- Providing accessible, experiential learning embedded in an existing course.
- Using selective enrollment to target a specific disciplinary mix of students and students traditionally underrepresented in STEM fields.
- Developing spin-off Summer / Wintermester online course that use virtual reality to place virtual students on the site, use of recording from spring studio site to provide students an immersive experience from any location. Continued delivery of the class would allow the development of a library of virtual real-world simulations.

In addition to the 4-VA grant requirements, other outcomes will be met through our dissemination efforts in the interim between course deliveries each spring semester:

- Participation in academic conferences, such as, the American Society of Engineering Education Annual Conference, by principal investigators and graduate students, including preparation of conference manuscripts, presentations, and posters.
- Outreach to professional organizations for use of online course modules as professional development tools, such as, continuing education course offered through the American Society of Civil Engineers.
- Submission of articles describing methods of data analysis and findings to peer-reviewed journals such as *Journal of Planning Education and Research* and the *Journal of Professional Issues in Engineering Education and Practice.*

Impact to the institution

Our *Collaborative Redevelopment* course will present a novel and important addition to the curricula in engineering, planning, and real estate development, none of which currently have a learning opportunity that is both experiential and transdisciplinary. Yet, these students are expected to work collaboratively in the real world. Expansion to online courses with virtual learning will broaden access significantly. The course is consistent with the *Ut prosim* ethos of Virginia Tech through its community engagement component, with *Beyond Boundaries* through its targeting of transdisciplinary, hands-on, minds-on learning, and with both the *Data and Decision Sciences* Destination Area and Policy Strategic Growth Area.

Alignment to 4-VA

Table 3. Alignment of *Collaborative Redevelopment* with 4-VA goals

Increases **opportunities and success rate** for students in STEM	• Engineers rarely have curricular or non-curricular opportunities for thinking about community engagement strategies or working directly with the public on projects. • The course adds an experiential studio component currently not available in the engineering curriculum.
Defines or improves **instructional models**	• The course provides instructional effectiveness data via pre-/post- measurement of indicators of student understanding and analysis in three dimensions that are increasingly frequent educational targets: transdisciplinary thinking, sustainability, and engagement. • The course adds a transdisciplinary elective for engineering and planning students.
Increases access of students to preparation for **rewarding careers**	• Engineers frequently work with planners and developers in the development of the built environment, and employers value project-based experience grounded in real-world applications.
Increases **research competitiveness**	• The investigators have a longstanding collaboration around community decision-making at the land use / infrastructure interface. The course could function as both a component of broader impacts narratives and could also provide pilot data for research experience or curriculum development grants. • The course would provide a template for transdisciplinary broader impacts through course development and delivery, in a funding landscape that increasingly demands working across disciplinary boundaries and showing synergies between research and teaching.

Project management: Development, delivery, and dissemination

Table 4. Project management

YEAR ONE (AY 2018-2019)		
Description of task	Time frame	Team members
Development: Course module preparation (readings, case studies, quizzes, assignments) *Deliverable: Syllabus; Canvas course site*	Jul – Oct 2018	Shealy / Skuzinski
Development: Course promotion and review of prospective students *Deliverable: course visits; digital poster; applicant pool*	Oct – Dec 2018	
Delivery: Baseline data collection *Deliverable: Student database v. 1*	Jan 2019	
Delivery: Time 1, Time 2 data collection *Deliverable: Student database v. 2*	Feb – Mar 2019	
Delivery: Iterative adjustment of course content based on key findings from Time 1 data *Deliverable: Revised syllabus and Canvas course site*	Mar 2019	
Dissemination: Student conference poster preparation *Deliverable: Student posters*	May 2019	
Dissemination: Conference manuscript preparation *Deliverable: Working paper*	Jun – Jul 2019	
YEAR TWO (AY 2019-2020)		
Development: Preparation of online modules for delivery in Wintermester 2019/2020 and Summer 2020 *Deliverable: Draft Wintermester online modules*	Aug – Nov 2019	Shealy / Skuzinski
Development: Iterative adjustment of course content based on key findings from previous delivery *Deliverable: Revised syllabus and Canvas course content*	Nov 2020	
Delivery: Wintermester online course *Deliverable: Finalized Wintermester online modules*	Jan 2020	
Delivery: Baseline data collection *Deliverable: Student database v. 3*	Jan 2020	
Delivery: Time 1, Time 2 data collection *Deliverable: Student database v. 2*	Feb – Mar 2020	
Delivery: Iterative adjustment of course content based on key findings from Time 1 data *Deliverable: Revised syllabus and Canvas course site*	Mar 2020	
Dissemination: Student conference poster preparation *Deliverable: Student posters*	May 2020	
Dissemination: Peer reviewed manuscript preparation *Deliverable: Journal submission*	Apr - Jun 2020	
Dissemination: Conversion of online modules from summer and winter semesters for broad-based, online dissemination *Deliverable: Online course through Coursera or similar platform*	May – Jun 2020	

Budget

Category	Amount	Justification
Salaries		
PI Summer Salary—Skuzinski	$22,915 (three summers)	$8,120 (2018)—four weeks $8,347 (2019)—four weeks $6,448 (2020)—three weeks *Assumes 3% annual base salary increase. Course preparation for studio and online courses, manuscript preparation, dissemination efforts.*
PI Summer Salary—Shealy	$25,225 (three summers)	$9,000 (2018)—four weeks $9,270 (2019)—four weeks $6,953 (2020)—three weeks *Assumes 3% annual base salary increase. Course preparation for studio and online courses, manuscript preparation, dissemination efforts.*
Graduate Student Wages/Stipend	$20,000 (two students, two semesters each)	$25/hr wage for 10/hr week assistance over 20 weeks for student in CEE and student in MURP *(spring 2019 and spring 2020 course delivery (data collection and analysis, grading, course prep))*
Printing costs for conference posters	$500	$250 for estimated five student posters, across two course deliveries.
Travel—course site visits	$2,100	Seven visits for on-site studio sessions, $150/visit for food, transportation, and incidentals, across two course deliveries.
Travel—professional development dissemination	$10,000	Ten trips to regional (mid-Atlantic and southeast U.S.) professional development organizations, budgeted at $1,000 each for lodging and transportation.
Travel—conference dissemination	$10,000	Six conference trips to national and state conferences in engineering and planning, budgeted at $2,000 each for lodging and transportation for national conferences, and $1,000 each for state conferences.
Publication Costs	$500.00	
Total	**$91,241**	

References

Allen, D., Allenby, B., Bridges, M., Crittenden, J., Davidson, C., Hendrickson, C., Matthews, S., Murphy, C., and Pijawka, D. (2009). "Benchmarking sustainable engineering education: Final report." EPA Grant X3-83235101-0.

Allenby, B. (2011). "Rethinking engineering education." Proc., IEEE International Symposium on Sustainable Systems and Technology (ISSST), Chicago, IL.

Bielefeldt, A. (2013). "Pedagogies to Achieve Sustainability Learning Outcomes in Civil and Environmental Engineering Students." Sustainability, 5, 4479-4501.

Attachments:

- Signed Department Support Letter (Civil and Environmental Engineering)