ABSTRACT

Civil engineering has long dominated transportation organizations that utilize engineering expertise to plan, design, and construct transportation facilities. In turn, universities have responded successfully to the call to produce graduates who can perform those tasks. In recent times, however, a multi-disciplinary approach to delivering transportation solutions is being advocated to support the planning and environmental objectives of federal legislation. One clear need is to educate the transportation workforce about the relationship between transportation infrastructure, communities, and the natural environment. Context sensitive solutions (CSS) addresses the need to consider the community and environmental inputs for successful transportation projects. Introducing CSS principles into university transportation curricula can enhance the skills and abilities of college graduates entering transportation, although challenges exist. The Center for Transportation and the Environment (CTE) and the Department of Civil, Construction, and Environmental Engineering (CCE) at North Carolina State University (NCSU) are finding ways to address these challenges. First, CCE faculty have integrated CSS into undergraduate and graduate courses within the department. Second, CTE and the CCE Department have partnered with the NC Department of Transportation to establish the CSS Academy, an undergraduate internship program, where students experience real-world CSS applications. Third, under Federal Highway Administration sponsorship, CTE and CCE are developing a CSS graduate course to be pilot tested at NCSU and distributed nationwide. These efforts provide a classroom model of the multi-disciplinary approach required for successful CSS implementation. This paper summarizes the CSS curriculum efforts at NCSU and offers ideas on future needs for university transportation education.
INTRODUCTION

Civil engineering has long dominated transportation organizations that utilize engineering expertise to plan, design, and construct transportation facilities. In turn, universities have responded successfully to the call to produce graduates who can perform those tasks. In recent times, however, a multi-disciplinary approach to delivering transportation solutions is being advocated to support primarily the planning and environmental objectives of federal and state legislation.

In addition to legislative mandates that promote collaboration among disciplines, two other factors are forcing movement in this direction. The American Society for Civil Engineers (ASCE) 2005 Report Card for America’s Infrastructure states that the nation’s massive transportation infrastructure continues in a state of decline, while many U.S. cities are experiencing rapid growth in population. (1) Since the 2001 grades were issued, ASCE reports that the nation’s infrastructure has shown little to no improvement (receiving a D grade point average overall), with some areas showing falling grades. The nation’s roads in particular went from a D+ to a D at a cost of more than $54 billion to Americans in repairs and operating costs. This state of affairs would suggest that civil engineers are needed now more than ever, but according to the U.S. Bureau of Statistics, civil engineering enrollments in universities have been declining since 1994, and while the numbers are beginning to increase, they are expected to rise only 8 percent from 2002 to 2012, a slower than average rate for all occupations. (2) Add to this the fact that globalization is now on the scene and changing America’s civil engineering workforce in unpredictable ways (3), and you have a clear message to university civil engineering programs that it is time to take notice and to adapt their curricula and recruitment programs accordingly.

Civil Engineering magazine recently reported that all of these factors are creating a “growing demand for a new kind of civil engineer—flexible, more broadly educated, and better prepared to meet the challenges of the future.” (3) Jay Lund, professor of civil and environmental engineering at the University of California-Davis, states that filling the labor void is a critical objective, but the university is equally interested in grooming well-rounded graduates. “Universities are seeking to produce civil engineers with more people skills that can gel with a team of professionals from other disciplines.” Lund says humanities and social sciences classes can help produce well-rounded civil engineering graduates. (4)

Concentrated efforts are underway within the federal government and private sector to educate the transportation workforce about the dynamic relationship between transportation infrastructure, communities, and the natural environment, including the importance of adopting a multi-disciplinary approach to addressing the challenges posed by this relationship. Within the last five years much of this education has focused on teaching the principles and concepts of context sensitive solutions (CSS), a planning and decision-making technique that helps transportation professionals consider not only the safety and mobility needs, but also the broader community and environmental inputs for successful transportation projects.

Unfortunately, introducing CSS principles into university transportation education has been a slow process by comparison. However, with a high percentage of the senior transportation workforce headed toward retirement, there is a clear need to integrate CSS concepts into university transportation programs. A strong knowledge of CSS can enhance the skills and abilities of new college graduates entering the transportation field during one of its most challenging periods. Without question, there are certain constraints that may hinder the ability of
an academic department to meet this objective, constraints both internal and external to the university environment.

The Center for Transportation and the Environment (CTE) and the Department of Civil, Construction, and Environmental Engineering (CCE) at North Carolina State University (NCSU) are finding ways to address these challenges through three unique initiatives. First, CCE faculty have integrated CSS into undergraduate and graduate courses within the department. Second, CTE and the CCE Department have partnered with the NC Department of Transportation (NCDOT) to establish the CSS Academy, an undergraduate internship program, where students experience real-world CSS applications. Third, under Federal Highway Administration (FHWA) sponsorship, CTE and CCE are developing a CSS graduate course to be pilot tested at NCSU and distributed nationwide. These efforts are providing a classroom model of the multi-disciplinary approach required for successful CSS implementation. This paper summarizes the CSS curriculum efforts at NCSU and offers ideas on future needs for university transportation education.

INTEGRATING CSS INTO UNDERGRADUATE AND GRADUATE COURSES

CSS in Highway Design
Within NC State’s CCE department, the most significant amount of content on context sensitive solutions is contained within the “Highway Design” graduate course in civil engineering. Highway Design is a three-credit class offered every other year to seniors and graduate students. It typically attracts about 30 students, roughly half of whom are graduate students.

The CSS content in Highway Design is located primarily in the first part of the course, when the learning objective is to specify a desirable horizontal and vertical alignment for a highway, given a set of design controls. One lecture (of 29 during the semester) is devoted to understanding the project development process, while another is devoted to selecting suitable corridors. During those lectures, the instructor presents the concept of CSS, talks about stakeholders, and shows the typical public involvement process for a large NCDOT highway project. The instructor also discusses environmental issues and constraints and the permitting process. In some years the course also includes a field trip to a public meeting on a transportation project, but this is only possible when a meeting on a substantial project is held near campus at a convenient time.

The highlight of this course is an interactive, experiential learning exercise in which students debate controversial highway cases that the instructor has accumulated through the years. During this exercise, groups of two or three students act as stakeholders who hold a particular point of view on a case. For example, in one case study, a student group would act like the department of transportation, another would act like the chamber of commerce, another like the homeowner’s association, and another like the local environmental club. Given a map of the relevant area and the “purpose and need” for the highway project in the area, each group will assemble its recommended corridor or transportation alternative and make a short presentation to the rest of the class defending its recommendation. The class, after hearing presentations on the project case from all groups, acts like a jury and votes on the presentation that made the best recommendation.

In less than one class period, this short exercise quickly communicates the fundamentals of CSS in an effective and fun way.
CSS Skills in Other Courses
While the course described above is the main one in which CSS skills are taught to undergraduate students in civil engineering at NC State, there are other courses that teach related skills.

About half the undergraduate students in the department take a one-credit course in the applications of global positioning systems and geographic information systems (GISs). The latter is a particularly useful CSS-related skill. Students emerge from that course knowing what GIS is and how it can be used in civil engineering, and, through a couple of laboratory exercises, how to use some of the functions and commands of a GIS program. More than half the undergraduate students in the department take a hydrology course, where managing the extent and quality of runoff is a major theme. About one-quarter of the undergraduate students in the CCE department are enrolled in a construction degree program, wherein they learn a variety of CSS-related topics in construction like noise, dust, and silt mitigation. In addition, about half of the undergraduate students in our department take a public speaking course taught by the Department of Communications. While not focused on the dynamics of an engineer facing a potentially-hostile public regarding a transportation project, the course does provide background in the fundamentals and some public speaking experience.

Finally, NC State civil engineering undergraduates pick up much of the “context” for their future applications of CSS from their humanities and social science courses. The undergraduate civil engineering curricula basically require a student to take five courses from a menu of almost 1,000 approved courses. Students must choose at least one course from each of several categories and some courses have difficult prerequisites for civil engineering students to achieve, so there is not complete freedom on the students’ part, but it is still a very flexible system. It is not hard to find courses on the menu that have some relevance to CSS, such as:

- American Environmental History
- Social History of the New South
- Aesthetics and Design
- Landscape History
- Introduction to Environment and Behavior for Designers
- Physical Anthropology
- US Environmental Law and Politics
- Cultural Geography
- Community Relationships
- Urban Sociology
- Environmental Ethics
- Humans and the Environment

Because the menu is so large and most students choose humanities and social sciences classes for reasons other than relevance to future careers, we believe that only a few of our students take courses like those listed here.

CSS Graduate Course
Even with these efforts to integrate CSS information into the civil engineering curriculum, there is a need to provide students with a more holistic framework for applying CSS principles – and one specifically targeted to graduate students.
There is a concern that the current job market for civil engineers may make it harder for students to get into graduate school, yet, as expressed by Jay Lund of the University of California-Davis, most would agree that the “profession needs a certain number of people trained at higher levels. If the market is too good for people at the entry level, then the profession might not advance as fast as it could.” (4)

CTE, with financial support from FHWA, is developing a transportation-related CSS course targeted for graduate students in civil engineering or planning programs. The objectives of the course are 1) to provide students with a comprehensive understanding of CSS in transportation decision-making and technical processes; and 2) to provide an opportunity for them to apply CSS principles in their chosen transportation discipline. Therefore, a substantial portion of the course will involve case studies and projects where students will demonstrate their understanding and proficiency in integrating CSS into the various aspects of transportation planning and project implementation.

CTE has formed a national advisory panel to assist with the curriculum development. Panel members are current faculty in civil engineering, transportation planning, or landscape architecture schools at eight universities around the country. Members of the panel from outside North Carolina will be provided a grant to develop case studies relevant to their geographic area and the final CSS graduate course will be scheduled at each of these universities shortly after the completion of the pilot offering.

The CSS Academy
Beyond the walls of NC State’s CCE department, civil engineering students are able to participate in a much more concentrated CSS education initiative through the CSS Summer Academy.

The CSS Academy is a summer-time academic and internship program sponsored by NCDOT, CTE, and NCSU. One valuable aspect of this partnership is that more intensive instruction in CSS concepts can be provided to students more quickly because the partnership allows faculty to bypass the huge administrative burdens associated with proposing content changes to the existing curriculum. Further, according to the National Association of Colleges and Employers internship programs offer the most effective means of attracting and hiring new college graduates. (5) Accordingly, the objectives of the CSS Academy are to

- Introduce a select group of students (i.e., students who already have an interest in transportation careers) to the state of the art in CSS principles and practices in highway planning and construction.
- Recruit more well-rounded students to the transportation profession.
- Develop and test case study materials that can be transferred to a broader university classroom experience.

The inaugural CSS Academy, conducted in the summer of 2004, admitted six scholars who were rising senior college students interested in transportation and the environment. The academy provided a three-month paid internship with NCDOT that placed the students in summer jobs that blended traditional transportation engineering with contemporary CSS tasks. For example, two scholars majoring in environmental engineering worked for the NCDOT Roadside Environment Unit and measured the flow of nearby streams. Two other scholars majoring in civil engineering worked for the Construction and Hydraulics Units and became
project inspector apprentices. Another scholar worked for the Public Involvement Unit, and the last scholar worked at a regional transit management center. Each scholar was particularly concerned with the impacts of transportation projects and operations on the community and the environment.

In addition to the paid internships, the scholars received 12 days of CSS instruction in the classroom as well as experiential activities in the field. During the first week of their internships the scholars met their new supervisors and co-workers, received job assignments, and attended a day of CSS Academy briefings on the purpose of the Academy, the summer schedule, CSS concepts, and expectations for the summer.

In addition to their day-to-day responsibilities with NCDOT, the Academy scheduled the scholars to: 1) attend a three-day CSS workshop with their instructors and other NCDOT employees; 2) visit seven significant NCDOT projects that exemplify CSS principles; 3) meet several days to work on their individual CSS case studies; and 4) present their case studies to Academy instructors, NCDOT supervisors and CTE staff.

CSS Workshop
The three-day CSS workshop, which is sponsored by CTE and NCDOT, occurred during the second week of the Academy. Besides the CSS Academy Scholars, Academy instructors, NCDOT staff, and a few consultants also attended the intensive three-day workshop.

The workshop covered a variety of topics to prepare the Academy Scholars and long-time transportation employees for contemporary CSS approaches to transportation engineering. Topics included the following:

- Overview of CSS
- The Meaning of “Context”
- Techniques for Communication and Collaboration
- Stakeholder Involvement and Role Playing for a Case Study
- Transportation Decision Making and Environmental Considerations
- Context Sensitive Solutions for Construction, Operations and Maintenance
- CSS versus Design Criteria and Design Flexibility
- Legal Benefits of CSS

The highlight of the CSS workshop was a half-day case study including role-playing. The Academy Scholars worked side-by-side with experienced professional engineers to address the transportation needs of a hypothetical rural community. Of particular interest to all participants was the sea change in attitudes from traditional “business as usual” approaches to transportation construction and maintenance to an acceptance of CSS and a willingness to apply the concepts learned in the workshop.

CSS Field Trips
The field trips to NCDOT projects with a significant amount of context sensitive issues and solutions occurred in the fourth and fifth weeks of the Academy, and without question, they were the highlights of the Academy.

First, the students visited the Martin Luther King Expressway project in Wilmington, NC. This seven-mile project showed the students how significant community and environmental impacts can be minimized or avoided altogether. The issues included minimizing wetland
impacts, reducing noise impacts at a film studio, avoiding hazardous waste sites, reducing vibrations on nearby laboratory instruments, accommodating existing and future railroad corridors, tying into an existing bridge, expanding the historic area, and avoiding a 75-year old magnolia tree. This site visit illustrated real-world context sensitive solutions that were previously introduced in the classroom workshop.

After the morning site visit to the MLK Expressway, the students attended an afternoon workshop in Fayetteville, NC, near Fort Bragg. NCDOT staff and consultants presented final alignment alternatives for an expressway to link Fayetteville to Fort Bragg. While the MLK Expressway focused on environmental impacts and technical solutions, the Fayetteville Expressway workshop introduced the scholars to the real-life, personal impacts of a highway project infringing on homes and business properties. This experience, perhaps more than any other, illustrated to the scholars the value of good planning, design, and community participation.

A week later the scholars and their instructors traveled to the mountains of North Carolina to visit several projects that strongly illustrated CSS principles. These projects became the case studies for the scholars’ individual projects. The scholars met engineers and collected information for their cases that they developed in class and as on-the-job training during the remainder of the summer. The results of their project case studies were presented on the final day of the Academy.

The projects included the deep cut for I-26 at Buckner Gap near the NC-Tennessee border, improvements for US 321 through the resort community of Blowing Rock, Merrimon Avenue traffic operations improvements in Asheville, I-26/I-73 connector improvements in Asheville, and the Duraleigh Connector in Raleigh. The students collected public workshop and hearing information, EIS documentation, photography, project alignments, etc. They interviewed design engineers and reviewed public hearing summaries, if available. The students documented the CSS principles illustrated by the projects and explained why they succeeded (Buckner Gap), why they failed (I-26/I-40 “malfunction junction” and the Duraleigh Connector), and why there was a likelihood of future success (US 321 and Merrimon Avenue).

During these visits the students particularly appreciated the commentary from the design engineers who developed the context sensitive solutions for the projects. A shortcoming of the visits, however, was not having sufficient time to meet other stakeholders to gain their perspectives on the CSS issues.

**CSS Academy Class Time**

Twice before and twice after the field trips the scholars met to work on their case studies. The quality of the cases indicated that they also worked after hours on them. During class the instructors presented model cases for discussion and to establish a framework for the scholars’ cases. Major topics in the cases included the following:

- Project Location and Description
- Summary Purpose and Need
- History of the Project
- Context-Sensitive Factors
- Highway Agency Involvement (Partnerships)
- Significant Issues
  - Natural Environment
  - Human Environment
- Public Education and Involvement
• Design Issues and Special Features
  o Design Speed
  o Right-of-Way and Clear Zones
  o Number of Lanes and Lane Width
• Adjacent Land Use and Special Features
• Project Development Schedule/Milestones
• Costs
• Project Outcome and Lessons Learned
• Route Diagram and Photographs
• References and Sources

On the last day of the Academy the scholars presented their cases and turned in their case studies. These documents and presentations are valuable first additions to what the instructors hope will become a library of CSS cases and study materials for future Academies and for university classes.

Lessons Learned from the CSS Academy
From the instructors’ perspective the CSS Academy was an exceptional opportunity. Not often do instructors have the good fortune to work with a small group of talented students in the field. Such opportunities are usually constrained by conventional class sizes and formats, and they are limited to summer-time and research experiences.

Based on the students’ evaluations of the Academy the instructors can continue to improve the Academy in several ways.
• Engage the students in “active learning” in the field and in the classroom. For example, eliminate CSS project site visit “drive-bys” and develop specific tasks to accomplish during site visits. Such tasks include:
  o Describe clearly the purpose and need for each project site visited.
  o Define the environmental and community context of the project.
  o Identify potential environmental and community impacts of the project.
  o List alternative context sensitive solutions to mitigate project impacts.
  o Discuss the tradeoffs among the solutions in terms of time and cost versus effectiveness in accomplishing the project purpose and need.
• Complement case study lectures with more discussions and role-playing, similar to what was described in the CCE department’s Highway Design graduate course.
• Include focused case studies to identify, diagnose, and rectify a specific CSS issue at a project stage such as planning, review, design, and public hearing.
• Include a balanced set of cases that illustrate relatively small-scale CSS success stories (stream restoration, culvert and bridge design, roadside drainage, maintenance and operations), as well as large-scale construction projects.
• Use one, multi-faceted case study that can illustrate a variety of CSS issues and solutions instead of several case studies.

Clearly choices must be made depending on time and resources for the Academy, the teaching style of the instructors, and the learning mode of the students. Future Academies and university courses, however, will benefit from the experiences and documented case studies from the first CSS Academy.
EDUCATION NEEDS
The next few paragraphs will describe our vision of educational needs in CSS, primarily for university transportation programs, but also for professionals, as CSS training for the existing workforce continues to be a prevailing need. We are writing from the viewpoint of transportation professionals who typically hold degrees in civil engineering. Other academic disciplines would certainly have different points of view.

Undergraduate Level

Size of the Problem
As already established in this paper’s introduction, transportation engineering professionals need CSS training. Most of the transportation professionals who need the training do not have graduate degrees, so the bulk of the training will have to occur at the undergraduate level or in non-credit courses.

Evidence for this assertion is available from the American Society for Engineering Education (ASEE) or other groups that track graduation data. For example, in 2001-2002 the ASEE reported that American universities awarded 8,799 bachelor’s degrees in civil engineering and 3,785 master’s degrees in civil engineering (6). If this ratio of bachelor’s to master’s degrees has held steady for some time and applies to practicing transportation engineers, then it is easy to see that over half of the engineers needing CSS education will not have master’s degrees.

Of course, the population of transportation professionals needing CSS education also includes many non-engineers and persons without bachelor’s degrees, so the actual proportion of CSS trainees with master’s degrees in civil engineering will be far lower than half. In other words, much good could be done by offering CSS education primarily at the undergraduate level in civil engineering.

Not Covered in our Curriculum
Unfortunately, if NC State is representative of many civil engineering programs, and we suspect it is, there are many CSS skills and topics not covered in the undergraduate civil engineering curriculum.

Earlier in the paper we listed some of the CSS skills and topics that civil engineering undergraduates at NC State could pick up, including the overall concept, case studies, the environmental review process, public speaking, and some “context” like history and sociology in humanities and social science courses. However, one must remember that most undergraduates will not take all of those courses we described earlier, due to our very flexible curriculum. Also remember that the skills and topics described above are spread over a number of different courses rather than being provided under some unifying theme or even being labeled as “CSS,” so even students who have had most of the material we described might not recognize their achievement.

Probably the most glaring holes in the treatment of CSS at the undergraduate level in civil engineering at NC State are in the “management skills” that successful CSS professionals must employ. Our graduates get nothing formal in negotiation, running meetings, communicating with media, assembling information for public consumption, and other similar skills.
Constraints
If one wishes to add CSS education to the undergraduate curriculum, there are a couple bits of good news. First, good materials from which to teach are available from the National Cooperative Highway Research Program and other sources. Second, CSS education would not require any of the equipment or lab facilities that make many other parts of the engineering curriculum so expensive.

However, the good news is outweighed by a relative mountain of constraints that would make it difficult to start teaching more CSS in the undergraduate civil engineering program. These include:

- The presence of faculty able and willing to teach CSS. Most members of the current generation of civil engineering faculty do not have CSS training or experience.
- A hard cap on the number of credit hours in a bachelor’s degree program (imposed in North Carolina by the state government, for example) means nothing new gets added until something gets dropped.
- A “stovepipe” department and college structure within the university makes interdisciplinary courses and topics like CSS difficult to offer. Administrators stress taking care of students in their own programs first, and there is often little reward (or tangible losses) for teaching students from other departments.
- Great pressure on the humanities and social sciences faculty to teach a narrower set of “the classics of western civilization” instead of the flexible course menu with non-classics such as the courses listed earlier in this paper.
- The feeling that CSS skills are not fundamental to civil engineering. For example, CSS skills do not appear on the Fundamentals of Engineering exam and would not serve as prerequisites in other courses.
- Students need prerequisite knowledge to learn CSS that they will not accumulate until very late in their bachelor’s programs.
- CSS skills are not being requested in help wanted ads to this point. Students are receiving no market signals that CSS skills are desired by potential employers. By contrast, many private sector help wanted ads for transportation engineering bachelor’s candidates ask for computer-aided design (CAD) skills, so students are scrambling to obtain them.

Options
The constraints to increasing the coverage of CSS in the undergraduate civil engineering curriculum listed above are daunting. However, there are steps that NC State and other institutions could take to help overcome those obstacles.

One of these steps would be to provide support for faculty to acquire CSS skills and training. NCDOT graciously provided support for the faculty co-authors of this paper to attend ITRE’s CSS course, and similar opportunities must be provided for faculty at other universities until CSS-trained graduates start taking faculty positions.

One available option is to add a CSS course to the list of design electives seniors can take. There is no question that a CSS course with appropriately structured open-ended assignments would qualify as a “design” course for accreditation purposes. NC State offers a list of a dozen or so design courses from which juniors and seniors pick two. A new CSS course could simply be added to the list.
To advance further the cause of CSS education, universities could deepen liberal arts and management education opportunities and requirements. This might mean requiring more humanities and social sciences courses, if we could figure out something else to cut from the curriculum to make room for those. More likely, this would mean resisting proposed “return to the classics” reforms in this portion of the curriculum, and fighting to retain access to the relevant courses listed above. This would also likely mean advertising humanities and social science courses relevant to CSS to freshmen and sophomores, who typically take more of these courses but have little idea what might be relevant in their future career. At the extreme, we could require transportation students to take certain humanities and social courses.

Finally, it is essential to the success of an elective course that students start getting the idea that the course will help their career prospects. In turn, this means employers must start hiring graduates based on their CSS skills and education. Students will respond to market signals, and universities will follow.

**Graduate Level**

*Size of the Problem*

We made the case earlier that the bulk of CSS education and training in the U.S. needs to be focused at the bachelor’s degree or non-degree levels. However, there is still a sizeable opportunity to provide some of that education at the master’s level. Based on the annual number of master’s graduates in civil engineering, we estimate that there must be at least 1,000 graduates in transportation each year. If only half of those are in the planning, design, construction, or other areas with CSS interests, then the potential market for CSS courses at the master’s level in the U.S. must be at least 500 students per year.

*Not Covered in our Curriculum*

The CSS opportunities in the curriculum at NC State for master’s students are exactly the same as for bachelor’s students. That is because our elective courses, such as the Highway Design course, are available to undergraduate or graduate students. At the master’s level, of course, a student accumulates more courses and thus has more chances to fill holes in his or her preparation. However, the same major gap—relevant management skills—still applies at the master’s level at NC State and likely elsewhere.

*Constraints*

Many of the constraints on adding CSS content to the undergraduate curriculum listed above do not apply to the graduate curriculum. At NC State the transportation engineering graduate curriculum has no required courses. In addition, there is no humanities and social sciences requirement such as at the undergraduate level. Because the students are more advanced prerequisite knowledge is not a significant problem.

Finally, the stovepipe administrative structure is not as difficult to contend with as at the undergraduate level. At research institutions like NC State, faculty are encouraged to develop and offer graduate courses, and graduate courses rarely fill, so the prevailing attitude is, to some extent, just attract students to graduate courses from any department.

There are some serious constraints to adding CSS education at the graduate level, however, which include:
• A cap on the number of credit hours in the master’s program, imposed primarily to keep programs competitive with each other.

• Faculty do not want to reduce the numbers of students in existing courses. Thus, new courses must usually be shown have the potential to bring in new students, which CSS has not demonstrated to this point.

• CSS is not high-tech, which would put it at a competitive disadvantage for students and resources in engineering programs.

• Even at the master’s level, many students take courses with an eye on research that might lead to theses and dissertations. Since there is currently very little research in CSS being conducted at universities, few students are seeking courses for this reason.

• Distance education is an increasingly popular option in master’s programs. At NC State, distance education students typically account for around 10 percent of the student credit hours in the transportation engineering graduate program. However, a CSS course would involve much discussion, group work, and field trips, so CSS education via distance learning, given the current status of the technology at NC State and most other institutions, may not be an option for these students.

• As at the undergraduate level, CSS skills are not being requested in help wanted ads to this point.

Options
Despite the constraints to adding CSS to the graduate curriculum listed above, there are some options available to help make that possible. Larger programs could simply add a CSS course to their elective lists, even if that dilutes the current student pool. Creating a course without many prerequisites that would be open to students in other programs might help bring in students from those programs. Civil engineering students could add more relevant liberal arts and management courses to their plans of study. Many of the relevant CSS courses in the NC State humanities and social sciences menu listed above would be available to graduate students as well, for instance. As mentioned above for undergraduate students, relevant courses could be packaged and advertised to potential students. Funding research in CSS at universities would increase the number of interested students. Improving distance education technology to allow efficient participation by remote students in discussions would make CSS education available to them. Finally, as mentioned above, it is essential to the success of an elective course that students start getting the idea that the course will help their career prospects, which means employers must start hiring on the basis of CSS skills and education.

Professional Level

Size of the Problem
CSS training for transportation professionals continues to be a prevailing need and must be applied at a large scale in the U.S. in the coming years. One way to make a decent estimate at the number is to look at the example of North Carolina. As discussed elsewhere in the paper, NCDOT has sent over 1,000 professionals through the CSS training course at the Center for Transportation and the Environment in a relatively short time. North Carolina has about 100,000 miles of public roads (7), which averages 100 miles of road for each CSS-trained professional.

If one assumes that other states use transportation professional labor about as efficiently as in North Carolina, and those states wish to achieve the same level of CSS training that North
Carolina has achieved to this point, then given that the U.S. has about 3.9 million miles of public road (7), this would mean about 39,000 professionals need to be trained. Of course, in addition to this backlog of current professionals there would also be several thousand new professionals in the U.S. each year that would need to be trained if they did not receive earlier CSS education.

To this point, a few state DOTs like North Carolina’s have provided CSS training to their professionals. However, the authors believe that, even in those states, there are several groups of professionals who have largely not received any CSS education to this point. These include:

- City and county employees
- Private consultants
- Professionals in disciplines outside transportation

The last bullet point above follows from the recognition that CSS principles really should apply to any large public works project and many large private works project.

**Constraints**

There are serious obstacles to expanding CSS professional training to other state DOTs and the other groups needing training listed above. The main constraint appears to be the lack of certainty of payback to the employers, particularly at cash-strapped local governments and in private companies. Again, there are no strong market signals telling mangers that they need to send their people to CSS short courses. Other constraints include:

- There is a need for more trainers.
- Trainers could benefit from more case studies, especially in other disciplines besides transportation.
- As noted above, better technology would make CSS training available via distance education, saving travel costs for course attendees.

**Options**

At this point, the main educational need in CSS professional training is evidence of payback for companies and agencies that send their people to courses. Especially for private firms, they will need to see CSS mentioned in requests for proposals and consultant selection criteria before they commit. The three constraints listed in the bullet points above can be addressed with financial commitments from federal and state transportation agencies.

**CONCLUSION**

Context sensitive solutions training for professionals and the integration of CSS concepts in university transportation education programs can further the cause of producing more well-rounded civil engineers with a broader knowledge base and stronger communication and managerial skills. Clearly, this is the kind of civil engineer required to meet the challenges associated with the nation’s aging transportation infrastructure, rapid population growth, and human and natural environmental objectives – all within an era of economic globalization. The question remains to what extent will market forces establish CSS as a necessary skill set for transportation industry employees, and how quickly will universities be able to respond in turn?
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