AC 2012-5489: CORE CONCEPTS AND LEARNING OUTCOMES IN AN INTRODUCTORY TRANSPORTATION ENGINEERING COURSE: AN EVALUATION OF PILOT IMPLEMENTATIONS

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Since 2007, Shashi Nambisan has been the Director, Institute for Transportation (InTrans) and a professor of civil engineering at Iowa State University (ISU) in Ames, Iowa. He previously served on the faculty at the University of Nevada, Las Vegas for more than 17 years. He is a registered Professional Engineer in the state of Nevada. One of Nambisan's passions is the development of the future transportation workforce. He enjoys working with students. His advisees have developed successful professional careers at universities or in the private and public sectors. Many of them serve in leadership positions in professional societies. He has taught 18 different undergraduate and graduate courses related to transportation, as well as undergraduate capstone design courses. Nambisan also has been very active in leadership roles of several professional societies and organizations, such as the American Society of Civil Engineers (ASCE), American Society for Engineering Education (ASEE), Council of University Transportation Centers (CUTC), Institute of Transportation Engineers (ITE), and the Transportation Research Board (TRB). His current appointments include those as a member of the Educational Activities Committee, which reports to ASCE's Board of Direction; Chair of the ASEE Civil Engineering Division; member of the Executive Committee of CUTC; and member of the AASHTO Research Advisory Committee-CUTC Liaison Group.

For his contributions as an educator, researcher, and leader, Nambisan has received several awards and honors. Among the awards and honors he has received are the following: a proclamation by the Governor of Nevada designating Jan. 31, 2007 as the "Professor Shashi Nambisan Day" in recognition of his leadership role in and contributions to enhancing transportation safety, and the Harry Reid Silver State Research award in 2005.

Core Concepts and Learning Outcomes in an Introductory Transportation Engineering Course: An Evaluation of Pilot Implementations

Abstract

Over the last two and a half years, about 20 transportation engineering educators from 13 different colleges and universities across the United States have been working collaboratively on an initiative to develop and implement a set of core concepts and learning outcomes for a typical introductory transportation engineering course. This group has developed knowledge tables for the core concepts associated with traffic operations, transportation planning, geometric design, transportation finance, transportation economics, traffic safety, transit, non-motorized transport, and human factors. This paper describes pilot implementations in the introductory transportation engineering courses at three different institutions. The institutions have class enrollments ranging from 15 to 75. Preliminary results from one of the institutions were presented at the 2011 ASEE Annual Conference; this paper adds the results from two additional institutions, assesses the efficacy of the approach individually as well as comparatively, and identifies areas of strength and weakness. Finally, the paper discusses how the results of the pilot implementations are informing the efforts of the group in enhancing the approach, and for future implementation efforts.

Introduction

Transportation engineering workforce development in the university system is typically housed in civil engineering programs as one of several focus areas in the profession; others may include geotechnical, environmental, materials, structural, water resources and sometimes construction engineering. A study by Turochy in 2006 found that nearly all of the 224 civil engineering programs in the United States have one or two required transportation courses as part of the undergraduate curriculum.[1]

The transportation profession is approaching a forecasted workforce shortage with estimates of between 40 to 50 percent of the workforce eligible to retire in the next decade. [2,3] The pressures of urbanization, population growth and aging infrastructure will likely further increase the demand for well-trained transportation professionals.[4]

University-based civil engineering programs play a critical role in both the recruitment and training of future transportation professionals. A 2008 study by Agrawal and Dill looked at how civil engineering students choose a specialization area.[5] This study surveyed over 1,800 undergraduate students studying civil engineering at U.S. institutions in an effort to identify barriers to recruiting sufficient students to enter the transportation profession to address anticipated workforce shortages. One of the primary conclusions from the study was that the transportation profession needs to educate students about the merits of the field.

Past Efforts
In June of 2009, a Transportation Engineering Educators Conference brought together more than 60 transportation educators and professionals.[6] The challenges associated with the introductory transportation course emerged as one of the primary issues in transportation education. Since that conference a group of approximately 20 transportation engineering educators have collaborated to work on the issues raised at this conference. Last year the ad-hoc working group was formalized as the Curriculum Subcommittee to the ITE Education Council.

Over the past two and a half years, the Curriculum Subcommittee has used the concept of backwards course design to develop a set of course level learning outcomes and detailed knowledge tables in key content areas using a combination of verbs from Bloom's Taxonomy and Wiggins and McTighe's facets of understanding with a knowledge table structure.[7,8] Table 1 shows the current version of the course learning outcomes. The competencies listed in the first column are the core course learning outcomes. The remaining columns refer to increasingly more integrated use of the knowledge from the course learning outcomes both within the introductory course and subsequently. More details about the approach and results from these tasks can be found in articles by Beyerlein et al. and Sanford Bernhardt et al.[9,10]

Pilot Study

Faculty members at three institutions – Iowa State University, Lafayette College, and the University of Wyoming – have used the course learning outcomes and knowledge tables to revise their introductory transportation courses. The three institutions are in different parts of the country, with different missions, and different student body profiles. Enrollments in the introductory transportation course range from 15 to 75 students. In addition to improving the courses, the goal of these course revisions is to provide feedback to the ITE Curriculum Subcommittee on challenges and potential benefits of implementing the Subcommittee's work in a course. The following sections describe the survey administered to track changes in students' perceptions; discuss the changes made, survey results, and conclusions for each institution; and compare the results across the institutions.

Student Perception Survey

The faculty members involved in the pilot study administered initial and post perception surveys to students enrolled in the introductory transportation courses. Initial surveys were administered on or prior to the first day of class, and the post perception surveys were administered during the last week of class. The majority of the survey questions were taken from the previous research effort by Agrawal and Dill,[5] described in the Introduction to this paper, that looked at how civil engineering students choose a specialization area.[10] In addition to questions taken from the Agrawal and Dill study, survey questions inquired about the general level of interest in the transportation field and the level of rigor of the class. There were minor differences among the surveys administered at the three institutions; however, the majority of the survey was common among the institutions, and it is the responses to these common questions that are anayzed.

Table 1. Suggested Learning Outcomes for the Introductory Transportation Course

1. Competencies	**2. Movement**	**3. Experience**	**4. Integrated Performance**
1.1 Complete a geometric design for a section of a transportation facility. 1.2 Complete level of service analysis for basic freeway segment. 1.3 Complete signal timing design for fixed time isolated intersection. 1.4 Design and conduct a safety analysis 1.5 Forecast demand for a transportation system 1.6 Explain pavement design referring to standard design and procedures.	2.1 Able to apply the scientific method to transportation problems. 2.2 Able to explain relationship between components of the transportation delivery process and appreciate how course content supports these relationships. 2.3 Increased ability to connect theory with field observations and ability to identify limitations in theory/models	3.1 Connecting driving and pedestrian experiences with transportation terminology and common/classic transportation engineering problems (i.e. safety, congestion, energy, and the environment). 3.2 Heightened awareness of the global transportation system that connects producers and consumers	4.1 Integration of design, operations, and planning concepts to create a traffic impact analysis project. 4.2 Integration of complete streets principles in planning, design, and operations of a transportation system

The first question on the survey asked the students about their general level of interest in the transportation profession, with four points for being very interested to one point for the least interest. The second question gauged the student's opinion coming into the course on how rigorous they expected the course to be compared to the required courses in the other civil engineering disciplines. Concern that students perceive the introductory transportation course as not rigorous when compared to the other civil engineering disciplines was one of the motivating factors for the Transportation Engineering Education Conference[9]. The scale used for this question was: more rigorous (3 Points), similar in rigor (2 Points) and less rigorous (1 Points). Students were also asked to comment on whether the level of rigor of the class was view as a positive or negative. The remaining questions about specific perceptions of the profession were scored on a five point Likert scale with five points being most agreeable. For these questions, students could also provide a "Don't Know" response that was coded as a null value. All questions were coded so that higher values reflected more positively on the transportation profession than lower values. For all questions, improvements in the students' perceptions of the transportation field are indicated in final survey values that are higher than the initial survey results.

Institution One: Iowa State University

<u>Course Description and Summary of Course Changes</u>

The introductory Principles of Transportation Engineering course at Iowa State University is a required junior level course for all Civil Engineering (CE) majors in the Department of Civil, Construction, and Environmental Engineering. This includes all students in the CE program (both the General CE program and the CE program with an Environmental Engineering option). It is one of six required 300-level CE core courses in the CE program. Most students enroll in this course during their junior year in the program. CE majors also are required to take a senior level Highway Design course – this is not a required course for the other majors within the department. Many students in the department, primarily from among the CE majors, take one or more senior-level electives in transportation engineering. Further, transportation is a required element in every capstone design project in the Department's degree programs. Until the Spring 2011 semester, the Principles of Transportation Engineering course was a 2-credit course, and the Highway Engineering course was a 4-credit course. In order to address programmatic breadth and depth issues for all students in the department, the Transportation Engineering course and Highway Design Course were both modified to become 3-credit courses beginning in Fall 2011. These changes are reflected in changes in the syllabi for the two courses – with changes in the depth of materials addressed in the courses, particularly related to an increase in geometric design topics addressed in the Principles of Transportation Engineering course.

The introductory Transportation Engineering course has been offered every spring and fall semester and has been led by three different instructors over the past several years. The class enrollment has ranged between 55 and 75 students in each semester. This pilot study was conducted during the Fall 2011 semester; there were 75 students enrolled in the course initially; a few students dropped or withdrew from the course during the semester. The course was offered in a lecture-based format with three, 50-minute class periods weekly. One faculty member led the course for the first one-third of the semester, and another faculty member taught the course for the remainder of the semester. Additionally, the first instructor held three optional 2-hour long discussion sessions during the first six weeks of the semester; students were encouraged to attend all or part all of these sessions. The purpose of these sessions was to address any questions that the students had related to the course or on a broader array of transportation-related subjects, academic concerns, or career interests. The course aimed to provide a broad exposure to a variety of topics, with in-depth treatment of a few topics. The 4th edition of the textbook authored by Garber and Hoel, a popular and broadly used book across the nation, was used as for the course. While the book has significant breadth and depth of coverage of topics, the topics included in the course were limited both in breadth and depth. Instructor prepared handouts were used as supplementary core reference materials. These were posted online using the IT system adopted at the Institution.

The nationwide initiative to develop knowledge tables and learning outcomes influenced the topics addressed and the instructional approach adopted. This included refining the breadth and depth of topics addressed and relating the course objectives to the outcomes listed in Table 1. The student learning objectives for the course (excerpted from the syllabus and assignments) are as follows:

- *demonstrate skills and abilities to interpret and communicate the significance of information pertaining to various factors that influence transportation engineering projects - e.g. economics, environment, equity, finance, political, social.*
- *identify characteristics of design vehicle such as power, torque, and gearing and the elements of braking, including brake-force proportioning and braking efficiency and explain how these terms apply to actual road vehicles; compute road vehicle performance*

characteristics and estimate braking and stopping distances based on vehicle and human factors.

- *explain key elements that influence traffic flow, and describe queuing principles, and use appropriate tools to calculate traffic flow parameters and solve traffic flow models; use the queuing principles to estimate (both mathematically and graphically) total vehicle delay in a transportation network, as a result of queuing.*
- *explain the approach and methodologies used to conduct level of service analysis on roadway system elements; explain the terminology used in such analysis, and have the background needed to use the Highway Capacity Manual level of service software.*
- *define key elements of signal timing, explain the terminology, describe the signal timing theory; develop basic signal timing plans.*
- *describe the four-step planning process used in transportation planning, perform preliminary analyses to support transportation demand modeling, and evaluate their results.*

<u>Survey Results</u>

The student perception survey was administered to the students enrolled in the Transportation Engineering course during the Fall 2011 semester. The survey administered on the first day of class had responses from 69 students, and the end of the term survey had 63 responses. The results of these surveys are presented in Table 2, which also includes the results from the other two institutions.

The results show that, overall, over the course of the semester, there was nominal improvement in the scores for student perceptions for the following items:

- Working in transportation engineering involves
  - helping and serving others through personal interaction,
  - exploring, understanding, and predicting natural or social phenomena,
  - analyzing data to solve problems; and
- It would be easy to get a job in transportation engineering.

Conversely, there were declines in the scores for student perceptions for the following items:

- Course rigor in comparison to other courses;
- Working in transportation engineering involves
  - machines, tools, and materials,
  - leading and persuading others,
  - the creation and use of new knowledge; and
- A career in transportation is prestigious.

Other questions in the end of the semester survey related to student perceptions of the breadth (number of topics) and depth (level of detail) addressed in the course. The average scores for responses for these two questions were 4.7 and 4.6 (on a scale of 1 to 5, with 5 signifying strongly agree) respectively. For the question on breadth, 58 students (92 percent) responded that they felt that "just the right amount of topics" were addressed by the course. Likewise, 57 students (90 percent) responded that they felt that "just the right level of detail" was addressed in the course. Students were encouraged to provide descriptive comments for these two responses as well. The comments ranged from being in strong agreement with the "just right" perspective, to "I felt rushed," "I wish we spent more time on …," "we should have more concrete examples," as well as comments on some portions of the course being "better" than others. One student asked if some of the topics would be covered in other courses offered by the department.

Instructor Reflections

It was interesting to note that overall there was no major shift in student perceptions between the beginning and end of the semester. A majority of students indicated that transportation engineering was not their primary area of interest – they were enrolled in the course because it was a part of the core curriculum. Further, the student perceptions were fairly "positive" (above "average" or "neutral") at the beginning of the semester. It is difficult to effect significant change in attitudes and perceptions about transportation among such students in a single semester. It is also possible that, in attempting to strike a balance between the breadth and depth of topics addressed in the class, students may not have been provided enough level of detail on any topic; consequently, the instructor was not able to make a strong enough an impression on the students about these areas.

Institution 2: Lafayette College

Course Description and Summary of Course Changes

The introductory Transportation Engineering course at Lafayette College is one of six required "core" courses for the Civil Engineering major. All of these courses are offered once per year in a format in which students meet with the instructor for three 50-minute classroom sessions per week and one 3-hour lab session per week for a 14-week semester. Classroom sessions are capped at 36 students, and lab section caps range from 12-16 students, depending on the nature of the labs. Most students take the transportation course in the spring of the sophomore year, but those who have studied abroad during that semester and a handful of others take the course during the spring of the junior year. Enrollments for this course have been in the low 30s for the last several years.

The instructor involved in the pilot study has taught the course at Lafayette College for the past 10 years. For the last several years, the course has used Fircker and Whitford's textbook. Prior to the pilot study, the course syllabus included the following language:

> *The goals of this course are to help you learn to:*
> - *perform basic transportation engineering studies and calculations,*
> - *understand and use transportation terminology so you can work with other engineers on a transportation-related project, and*
> - *understand enough about transportation issues and solutions so you can participate in the public discourse about transportation problems.*
>
> *More specifically, by the end of this course, you will be able to:*
> - *describe qualitatively and quantitatively the human, vehicle, traffic, and operational systems characteristics that control facility design,*
> - *design the horizontal and vertical alignments of a highway section,*
> - *analyze the traffic characteristics of a transportation system,*
> - *apply transportation demand modeling techniques, and*
> - *communicate more effectively about transportation issues with both fellow engineers and non-engineers.*

For the pilot study, the course goals remained the same, but the outcomes were modified to reflect the competency outcomes listed in Table 1:

More specifically, by the end of this course, you will be able to:

- *complete a geometric design for a section of a transportation facility,*
- *complete a level of service and capacity analysis for a transportation facility,*
- *complete a signal timing design for a fixed time isolated intersection,*
- *design and conduct a safety analysis for a hazard location,*
- *forecast future travel demand for a transportation system,*
- *explain pavement design, referring to standard design and procedures, and*
- *communicate more effectively about transportation issues with both fellow engineers and non-engineers.*

Changes were made to the syllabus and course design to increase emphasis on geometric design and signal design, and to include pavement design. A lab session on geometric design was added, and a number of in-class activities were re-written. However, due to a variety of circumstances, including inclement weather, the syllabus was changed during the semester. As a result, the course did not reach the level of depth anticipated for signalized intersections, and pavement design was eliminated.

<u>Survey Results</u>

The initial and final surveys were administered electronically to the 34 students enrolled in the Transportation Engineering course for the Spring 2011 semester. All 34 completed the initial survey; 31 completed the final survey. Table 2 shows the survey results. By the end of the course, more students perceived that transportation engineering involves analyzing data to solve problems and that it would be easy to get a job in the field. The latter increase was statistically significant at the 95% level; the former was not statistically significant. There were no changes in students' perceptions that working in transportation engineering involves exploring, understanding, and predicting natural or social phenomena.

Student interest in the course and perceptions of rigor decreased slightly between the initial and final surveys; the former change was not statistically significant, and the latter was statistically significant at the 90% level. Student perceptions that working in transportation engineering involves helping and serving others through personal interaction; machines, tools, and materials; leading and persuading others and creating and using new knowledge all decreased, as did the perception that a career in transportation is prestigious. Changes in perceptions relating to the use of machines, tools, and materials; leading and persuading others, and creating and using new knowledge were all statistically significant at the 95% level; none of the other changes were statistically significant at either the 90% or 95% levels.

Approximately two-thirds of the students (21 of 31) felt that the breadth of the course was appropriate, and 84% (26 of 31) felt that the depth was "just right". Of the remaining students, nine of 31 thought not enough topics were covered, with three students expressing a desire for more on non-highway modes, and five believing that there was insufficient depth.

Instructor Reflections

Student perceptions of the pilot course were similar to perceptions of the course before it was modified. In reflecting on the course, the instructor realized that the changes made to the course were not as great in practice as they had been in the planning.

Institution 3: University of Wyoming

Course Description and Summary of Course Changes

The Civil Engineering Program at University of Wyoming requires a junior-level Transportation Engineering course. While many of the students take a follow-up course in transportation, the program only requires them to take one additional senior-level course in four of the five areas (environmental, geotechnical, structures, transportation, and water) offered. The required transportation course is one of eight junior level required courses that form the core of the civil engineering program.

The Transportation Engineering Course is offered every semester and is taught by different instructors on a rotating basis. The class enrollment averages around 25 students per semester and is capped to be no more than 40 students. Due to the time the class was offered for the pilot study the class enrollment was slightly lower with only 19 students. The course is structured as a traditional lecture course that meets three times per week for 50-minutes over the 15-week semester. The instructor involved in the pilot study taught the course once per year for seven years before implementing the pilot study changes for the Fall semester of 2010. The course content prior to the pilot study involved covering as many topics in the field of transportation engineering as possible using a popular transportation engineering textbook by Garber and Hoel that is over 1,200 pages in length. The course emphasized exposure to different topics rather than depth in any particular topic.

After involvement in the development of the knowledge tables and learning outcomes discussed previously, the course instructor decided to re-develop the course for the Fall 2010 semester using the knowledge tables and course outcomes to guide course content decisions. This process removed considerable breadth from the course, which provided time to introduce further depth into the most critical topics. Another major change to the course was the addition of a 1 hour and 45 minute lab section to the course. The lab section was scheduled weekly, but the intent was to offer 5-6 labs per semester on key topics and to also use the time for exams. Since the credit hours were not increased with the addition of lab a lecture period was canceled for each lab that was added.

It is difficult to accurately quantify the change in course content from one semester to another, but using the topics listed in the syllabus as a guide, the total number topics covered in the course was reduced by approximately 25%. As the lecture material for each topic was reworked the focus was to provide greater depth and to minimize breadth, so the overall content changes were likely much greater than 25%.

Decisions about course content in the pilot study were guided by the knowledge tables and course learning outcomes developed by the ITE Education Council Curriculum Subcommittee.

The course objectives for the pilot study were developed directly from the course learning outcomes developed by this effort and were listed in the course syllabus as:

When you have completed this course, you should be able to:

1. *Complete a geometric design for section of a transportation facility.*
2. *Complete a level of service and capacity analysis for a transportation facility.*
3. *Complete a signal timing design for a fixed time isolated intersection.*
4. *Design and conduct a safety analysis for a hazard location.*
5. *Forecast future travel demand for a transportation system.*
6. *Perform a flexible pavement thickness design.*

Survey Results

The student perception survey was administered to the 19 students enrolled in the Transportation Engineering course for the Fall 2010 semester. The results for the initial and final surveys are summarized in Table 2. The primary purpose for including the results from University of Wyoming in this paper are for comparison purposes against the other two institutions; the results of the work at the University of Wyoming are described in greater detail elsewhere.[11]

As seen in Table 2 there was an increased level of interest in transportation as a potential profession. There were also improvements in the perceptions involving the profession in: exploring, understanding and predicting natural and social phenomena; analyzing data to solve problems; being prestigious; and ability to find jobs. There were lower scores in the perceptions involving the profession in: working with machines, tools, and materials; and the creation and use of new knowledge. The perception in course rigor also was reduced slightly. No change was observed in the profession being involved in the areas of leading and persuading others and helping and serving others through personal interaction.

From a statistical standpoint, only the first question on level of interest in the transportation profession had a statistically significant difference between the initial and final survey results at a 95% confidence level with a p-value of 0.02. The difference in perception between the initial and final survey results for the questions relating to analyzing data to solve problems and a career in transportation being prestigious were significant at the 90% confidence levels with both having p-values of 0.06.

The final survey asked questions about how students felt about the breadth and depth of the course. Sixteen of the 17 students completing the survey (94%) felt that "just the right amount of topic" was covered in the course. One student indicated that more coverage of pavement materials should be added. With respect to depth 15 students (88%) felt the depth of the topics covered was satisfactory. The two remaining students indicated they wished that additional time could be spent on topics to provide a more complete picture.

Instructor Reflections

While the assessment of this pilot course using the knowledge tables and course learning outcomes indicates the course was improved there is always room for additional improvement. The instructor intends to remove one or two more topics from the course in order to expand and provide greater depth into the safety area of the transportation field.

Combined Survey Results

The initial and post survey responses from the three institutions were combined into a single data set to determine whether there were any additional inferences that could be made across the institutions. Combining the survey data yielded a data set with 121 initial and 111 post survey responses. When comparing the mean of the responses from the initial and post surveys it was found that only the question regarding the ability to get a job in the transportation field yielded a statistically significant improvement at the 95% confidence level. Looking only at changes in the mean from the initial to post surveys it was found that five of the nine areas showed a negative change. Table 3 summarizes the results from the combined data set.

In addition to looking at the change in student perceptions over the semester, the survey responses were also analyzed regarding where the students believe the strengths and weaknesses of the profession lie and how the areas changed relative to each other over the semester. Table 4 shows the rank and average response score (on a five point scale) for the eight perception items. While this study does not define a threshold between what is an acceptable level for student perceptions it can be seen from the table that most of the areas have average scores above 4.0 (corresponding to a response of agree) with only prestige and job availability falling below this level for the initial survey. The post survey averages also includes three more areas (helping and serving others, working with machines and materials, and leading and persuading others) falling below the 4.0 threshold.

Interpretation of the Results and Future Steps

The results of this study provide insight for the instructors of the introductory transportation course at the three institutions into what the students believe about the transportation profession both entering and after completing this course. These results can be used in determining how the courses should be revised in the future to address shortcomings in the desired core competency areas. The bigger questions are in determining what should be labeled a shortcoming, how much change constitutes “success”, and what the expectations should be for the course as a whole. The transportation profession is a broad and diverse field and the introductory course struggles with issues regarding the tradeoff between breadth versus depth of topics. It could be easy to see how too much emphasis on improving student perceptions in these areas could add to the existing challenges regarding course content. Regardless, the issues with workforce shortages and recruitment into the transportation profession fall in a large part on instructors of this course so student perceptions cannot be ignored.

The results from this pilot study reflect the higher numerical scores in the same categories for the items that were reported by Agrawal and Dill with a higher percentage of respondents “agreeing.” For the perception questions Agrawal and Dill examined the percent of students "agreeing" with each statement and categorized the results based on self-declared transportation and non-transportation students. It is interesting to note the divergence in opinion between transportation and non-transportation students. Future efforts should attempt to evaluate if such differences exist between students who express “significant interest” in transportation as a career choice. Additionally, it would be useful to include demographic characteristics (gender, ethnicity, age, etc.) in future efforts. In this pilot, some of these data were captured at Institution

1. Such data need to be captured at all the institutions. Additionally, the wording of some of the questions needs to be re-evaluated, and some questions need to be modified.

Table 2. Course Survey Results

	Institution 1 (Iowa State University)		Institution 2 (Lafayette College)		Institution 3 (University of Wyoming)	
Question	Initial (n=69)	Final (n=63)	Initial (n=34)	Final (n=31)	Initial (n=19)	Final (n=17)
	Avg (Std Dev)	Avg (Std Dev)	Avg (Std Dev)	Avg (Std Dev)	Avg (Std Dev)	Avg (Std Dev)
Which of the following best describes your interest in this course? [4 point scale]	2.42 (0.847)	2.41 (0.854)	2.18 (0.797)	1.97 (0.836)	2.28 (0.895)	2.85 (0.825)
How rigorous do you feel that this course will be compared to the other required junior-level Civil Engineering Courses? [3 point scale]	1.97 (0.342)	1.95 (0.556)	2.00 (0.492)	1.74 (0.631)	2.00 (0.000)	1.88 (0.332)
With respect to your response to the previous question on the rigor of the course, do you view this as a positive or negative aspect of the course? Comment box.	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A (N/A)
Working in transportation engineering involves helping and serving others through personal interaction.	4.06 (1.013)	4.08 (0.703)	4.03 (0.637)	3.83 (0.834)	3.88 (0.697)	3.88 (0.697)
Working in transportation engineering involves exploring, understanding, and predicting natural or social phenomena.	4.19 (0.670)	4.21 (0.544)	4.32 (0.638)	4.33 (0.480)	4.33 (0.686)	4.53 (0.514)
Working in transportation engineering involves machines, tools, and materials.	4.29 (0.621)	3.87 (0.959)	4.21 (0.696)	3.58 (1.03)	4.56 (0.511)	4.53 (0.624)
Working in transportation engineering involves analyzing data to solve problems.	4.57 (0.581)	4.60 (0.555)	4.62 (0.493)	4.74 (0.445)	4.56 (0.616)	4.82 (0.393)
Working in transportation engineering involves leading and persuading others.	4.10 (0.900)	3.90 (0.665)	4.27 (0.626)	3.90 (0.790)	4.12 (0.485)	4.12 (0.928)
Working in transportation engineering involves creating and using new knowledge.	4.42 (0.553)	4.29 (0.658)	4.15 (0.558)	3.61 (0.882)	4.28 (0.669)	3.94 (0.659)
A career in transportation engineering is prestigious.	3.75 (1.106)	3.73 (0.884)	3.34 (0.827)	3.23 (1.02)	3.53 (0.624)	3.82 (0.529)
It would be easy to get a job in transportation engineering.	2.84 (1.277)	3.05 (1.007)	2.74 (0.656)	3.44 (0.751)	3.36 (0.929)	3.42 (0.669)

Table 3. Combined Results from the Three Institutions

Increased Perception	Decreased Perception
General level of interest in the transportation profession	Working in transportation engineering involves helping and serving others through personal interaction.
Working in transportation engineering involves exploring, understanding, and predicting natural or social phenomena.	Working in transportation engineering involves machines, tools, and materials.
Working in transportation engineering involves analyzing data to solve problems.	Working in transportation engineering involves leading and persuading others.
It would be easy to get a job in transportation engineering.*	Working in transportation engineering involves creating and using new knowledge.
	A career in transportation engineering is prestigious.

* Indicates a statistically significant difference in the means between the initial and post survey results at the 95% confidence level.

Table 4. Relative Ranks of Key items for Data Combined from the Three Institutions

Perception Area	Initial Survey		End of Term Survey	
	Rank	Avg*	Rank	Avg*
Working in transportation engineering involves helping and serving others through personal interaction.	6	4.09	4	3.98
Working in transportation engineering involves exploring, understanding, and predicting natural or social phenomena.	4	4.25	2	4.29
Working in transportation engineering involves machines, tools, and materials.	3	4.31	6	3.89
Working in transportation engineering involves analyzing data to solve problems.	1	4.58	1	4.68
Working in transportation engineering involves leading and persuading others.	5	4.19	5	3.94
Working in transportation engineering involves creating and using new knowledge.	2	4.32	3	4.05
A career in transportation engineering is prestigious.	7	3.67	7	3.60
It would be easy to get a job in transportation engineering.	8	3.08	8	3.29

* Response scale: 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree

The purpose of the pilot study was to see whether implementing a new approach to course design in the introductory transportation course would have an effect on both the student perceptions of the material and on student learning. Improving student perceptions of the material is necessary to attract students to the profession, which addresses the critical workforce challenges discussed earlier in this paper. Improving student learning is the goal of any course.

As mentioned previously, the pilot study described in this paper is part of a larger effort focused on the introductory transportation course. This nationwide effort is developing course objectives and learning activities to support instructors of the introductory transportation course. As these learning activities are developed they will be tested in courses that will utilize the initial and post surveys to see how these learning activities impact both student perceptions along with additional assessment on student learning of the course objectives.

The next step beyond the pilot stage would be to administer the perceptions survey at other institutions who have participated over the past 2 years in deliberations related to developing the transportation engineering workforces of the future. Ultimately, the larger the number of institutions engaged, the better would be our understanding of the perceptions among students about transportation engineering careers. This is vitally important to being able to attract, excite, and engage students to become the transportation engineering professionals of the future.

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