

# **Development, Deployment, and Assessment of Activity-Based Transportation Courses**

Transportation Education Development Pilot Project  
Federal Highway Administration

Project Team:  
University of Idaho  
Portland State University  
University of Washington  
University of Alaska  
Washington State University

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## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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| 16. Abstract<br><br>This project developed four new activity-based transportation courses including "Traffic Signal Systems Operations and Design", "Understanding and Communicating Transportation Data", "Introduction to Freight Transportation", and "Rural Highway Design and Safety". The courses are learner-centered in which activities completed by students form the basis for their learning. The courses were offered fourteen times to a total of 195 students. Activity books that included 142 activities were developed for the four courses. The books and all supporting materials are available on the project web site. A number of assessments and evaluations were conducted to determine how effective the courses and materials were in meeting project objectives. The active learning style was a challenge for many students, as they were required to be prepared for class and to do "active" work during class. In general, there was an acceptance of the value of the active learning environments and how they positively contributed to student learning. |  |   |                      |
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## Table of Contents

|  |     |
|--|-----|
| Acknowledgements.....  | vii |
| Chapter 1. Introduction and Overview .....                                     | 1   |
| 1.1 What is the Transportation Education Development Pilot Program?.....       | 1   |
| 1.2 What the Project Team Proposed.....  | 2   |
| 1.3 What the Project Team Did.....   | 5   |
| 1.4 What This Report Covers .....  | 6   |
| Chapter 2. Approach and Process.....   | 7   |
| 2.1 Overview and Timeline .....  | 7   |
| 2.2 Course Design Process .....  | 8   |
| 2.3 Deployment and Assessment Schedule.....                                    | 15  |
| Chapter 3. Products and Deliverables .....                                     | 17  |
| 3.1 University of Idaho Course.....  | 17  |
| 3.2 Portland State University Course.....                                      | 23  |
| 3.3 University of Washington Course .....                                      | 29  |
| 3.4 University of Alaska Course .....  | 33  |
| Chapter 4. Assessment and Evaluation .....                                     | 37  |
| 4.1 Student Perception of the Learning Environments and Learning Outcomes..... | 37  |
| 4.2 Effectiveness of Distance Learning .....                                   | 43  |
| 4.3 Student Conceptual Understanding .....                                     | 45  |
| 4.4 Evaluation of Developed Materials.....                                     | 54  |
| 4.5 Instructors Self-Reflections.....  | 63  |
| 4.6 Summary and Discussion .....   | 65  |
| Chapter 5. Results and Lessons Learned .....                                   | 67  |
| 5.1 Results.....   | 67  |
| 5.2 Lessons Learned.....   | 68  |
| Appendix. Project Web sites and Materials.....                                 | 71  |
| University of Idaho.....   | 71  |
| Portland State University.....   | 71  |
| University of Washington .....   | 71  |
| University of Alaska.....  | 71  |

## Table of Figures

|   |    |
|---|----|
| Figure 1. Project timeline: team meetings and workshops .....   | 8  |
| Figure 2. Course design process .....   | 9  |
| Figure 3. Types of Learning Outcomes .....  | 11 |
| Figure 4. Course delivery periods .....   | 15 |
| Figure 5. Course materials web site.....  | 18 |
| Figure 6. Companion web site .....  | 18 |
| Figure 7. Instructor resources web site .....   | 18 |
| Figure 8. Electronic flip book .....  | 18 |
| Figure 9. Organization of book .....  | 19 |
| Figure 10. Excerpt from Activity #10 .....  | 22 |
| Figure 11. Excerpt from facilitation guide, Activity #10 .....  | 23 |
| Figure 12. Course materials web site for Understanding and Communicating Multimodal<br>Transportation Data course .....           | 24 |
| Figure 13. Sample activity header.....  | 26 |
| Figure 14. Sample grading rubric and deliverable .....  | 27 |
| Figure 15. Sample plot showing the passenger loading in 30 minute steps for inbound route 19<br>trips (Credit: Joel Barnett)..... | 28 |
| Figure 16. Organization of course.....  | 29 |
| Figure 17. Course materials web site, Introduction to Freight Transportation course.....  | 30 |
| Figure 18. Excerpt from Activity #3.....  | 32 |
| Figure 19. Excerpt from facilitation guide .....  | 33 |
| Figure 20. Course materials web site for Rural Highway Design and Safety course .....   | 34 |
| Figure 21. Excerpt from Activity #4.....  | 36 |
| Figure 22. Learning styles .....  | 42 |

## Table of Tables

|  |    |
|--|----|
| Table 1. Course delivery data .....  | 16 |
| Table 2. Products resulting from this project .....  | 17 |
| Table 3. Activities for Traffic Signal Systems Operations and Design Course .....                            | 20 |
| Table 4. Activities for Traffic Signal Systems Operations and Design Course (continued).....                 | 21 |
| Table 5. Activities for Understanding and Communicating Multimodal Transportation Data<br>course.....        | 25 |
| Table 6. Material List for the Introduction to Freight Transportation course.....                            | 31 |
| Table 7. Activities for Rural Highway Design and Safety course .....   | 35 |
| Table 8. Common Assessment Questions and Responses .....   | 39 |
| Table 9. Common Assessment Questions and Responses (continued).....  | 40 |
| Table 10. Learning outcomes and traffic operations concepts .....  | 47 |
| Table 11. Participants in the comparative case study .....   | 48 |
| Table 12. Sample pre- and post- interview questions .....  | 48 |
| Table 13. Summary of results of conceptual understanding of concepts for all cases .....                     | 49 |
| Table 14. Concept inventory results .....  | 51 |
| Table 15. Student Responses in Pre- and Post- Course Surveys (Concept-related questions) ....                | 52 |
| Table 16. Student Responses in Pre- and Post- Course Surveys (Concept-related questions)<br>(continued)..... | 53 |
| Table 17. Activity assessment, University of Idaho .....   | 56 |
| Table 18. Portland State University, activity assessment.....  | 58 |
| Table 19. University of Washington, activity assessment .....  | 60 |
| Table 20. University of Alaska, activity assessment .....  | 63 |





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### *Project Team Members*

Michael Kyte (University of Idaho), Principal Investigator  
Steve Beyerlein (University of Idaho)  
Chris Monsere (Portland State University)  
Kelly Pitera (University of Washington)  
Ming Lee (University of Alaska)  
Shane Brown (Washington State University)  
Anne Goodchild (University of Washington)  
Nancy Nihan (University of Washington)

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## CHAPTER 1. INTRODUCTION AND OVERVIEW

This report describes the work completed by the University of Idaho and its four northwest regional partner universities (Portland State University, the University of Washington, the University of Alaska, and Washington State University) in developing, deploying, and assessing four activity-based learning courses in transportation. This first chapter of the report describes the Federal Highway Administration's Transportation Education Development Pilot Program (TEDPP) through which this project was funded, what we proposed to do, and what we completed as part of this project.

### 1.1 What is the Transportation Education Development Pilot Program?

The 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) provided funding through the Federal Highway Administration (FHWA) to develop transportation curriculum for all levels of the transportation workforce. The request for proposal for this program noted:

"The design, development and management of transportation programs has changed dramatically over the last decade and change is expected at an even faster rate as improved technologies, policies and processes require new workforce skills and management practices. The need to assure a skilled, technically competent workforce is especially challenging in transportation as evidenced by the variety of disciplines, management and technical skills, in both the private and public sector at the national, state and local levels.

"The combination of "baby boom" generation retirements, and changing technology and processes have raised serious concerns about the capacity and capability of the transportation workforce to deliver the Nation's transportation program now and in the future. FHWA defines workforce development as a continuum that begins with transportation career outreach for grades K-12, and continues with career preparation and development through community college, technical school, university and post-graduate education, and the on-going development of transportation professionals as they progress through their careers."

FHWA noted that TEDPP grant recipients could suggest a national strategy for curriculum development, develop and implement curriculum for K-12 grades or community colleges, coordinate regional or state curriculum develop, determine return on investment in training and workforce development, or other activities supporting workforce development including curriculum, education, training, or professional development programs. The University of Idaho team's proposal, focusing on the latter area, was selected by FHWA as one of four national projects to be funded under the TEDPP with a four year grant of nearly \$1.2 million.

### 1.2 What the Project Team Proposed

In preparing our original proposal to FHWA, we focused on a crucial component of workforce development, curriculum for university students and practicing professionals, but with a new perspective: creating an environment in which students were expected to be active participants in their own learning.

Our goal was to develop courses that would (1) attract new students to the field of transportation engineering and (2) train and retain practicing professionals by creating learner-centered educational environments that address crucial issues in transportation engineering and planning. To meet this goal, we established the following objectives that would guide our work during the project:

- Develop a set of four courses and the relevant learning materials based on the principles of active, problem-based learning
- Develop distance-separated, interactive learning environments based on sound educational practices in which the courses could be deployed and tested
- Create teams of students and practitioners to pilot test materials
- Design and implement a detailed evaluation and improvement cycle for each course
- Assess the learning process and student outcomes
- Disseminate what we've learned in this project to a national audience

We proposed that the course curricula would be learner-centered, built upon the extensive experience of the project team members in creating active, problem-based learning environments for transportation students. A substantial body of pedagogical research funded through the National Science Foundation and others demonstrates that problem-based environments produce students who perform better at solving novel problems and other positive learning outcomes.<sup>1</sup>

### The Educational Problem

The underlying motivation for this project was the recognition that a compelling need exists in the transportation industry for the development and retention of a skilled, technically competent workforce. The transportation industry in the United States is growing. According to the Bureau of Labor Statistics, transportation sector employment is expected to have increased 16 percent between 1998 and 2008.<sup>2</sup> Yet, a significant number of professionals are reaching retirement age; approximately 42 percent of state and local government employees are between the ages of 45 and 64.<sup>3</sup> And, while the industry relies upon an educational “pipeline” of students to fill these positions, enrollment in relevant degree programs is down and agencies

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<sup>1</sup> Duncan-Hewitt, Wendy, “Problem-Based Learning”, p 243, in “Faculty Guidebook”, Steven Beyerlein, Carol Holmes, and Daniel Apple, Pacific Crest, Lisle, IL, 2007.

<sup>2</sup> Polzin, S.E, and B.G. Ward. Designing an Interdisciplinary Educational Program to Support Transportation Workforce Development. In Transportation Research Record: Journal of the Transportation Research Board, No. 1812, TRB, National Research Council, Washington, D.C., 2002, p. 143.

<sup>3</sup> Martin, Clark. Help Wanted- Meeting the Need for Tomorrow’s Transportation Workforce. Public Roads, Vol. 65, No. 1, 2001.

must recruit from other professions. The financial reality in state and local agencies is that while program budgets continue to grow, many state legislatures seek to reduce the size of agencies, including state departments of transportation.<sup>4</sup> Downsizing in these departments has resulted in increased outsourcing to consulting firms as well as a loss of agency knowledge base and skills. The Idaho Transportation Department, for example, contracts out 70 percent of its design work.<sup>5</sup> This use of contractors has created a “distance separated” work environment, which demands a new set of collaborative, communication, and technology skills of the professionals involved.

Professionals in these agencies also face radical technological and market changes that require competency in a different arena of skill sets. Not only must they possess the technical competencies of their field, but also a “host of capabilities” including information technology, financial and human resources management, policy-making, and knowledge of the socio-political complexities of their region.<sup>6</sup> The multidisciplinary demands facing the 21st century transportation professional have been addressed in the research literature since the late 1990s, and the list of requisite professional qualities is extensive. Therefore, to promote competency and retention, training for all levels of the transportation workforce must be a key priority.<sup>7</sup>

The project team suggested that the solution to the problem facing the transportation industry is two-fold. Transportation agencies must partner with educational institutions to create programs that attract students to the profession and adequately train them. And, educational institutions must do their part to address training and retention issues by helping professionals experience competency and hone the technical skills needed to address modern transportation problems, which are inseparable from their complex technological, socio-political, and financial contexts.

### **A New Education Paradigm**

In order to respond to the transportation education and training needs addressed above, we proposed to develop, deploy, and assess a new learning environment and curricula that would attract more students to the field of transportation, help train and retain practicing professionals, and develop the technical skills of both groups in an innovative, yet cost-effective way.

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<sup>4</sup> Martin, Clark. Help Wanted- Meeting the Need for Tomorrow’s Transportation Workforce. Public Roads, Vol. 65, No. 1, 2001.

<sup>5</sup> Personal communication with Matthew Moore, Planning Administrator, Idaho Transportation Department, August 15, 2007.

<sup>6</sup> Polzin, S.E, and B.G. Ward. Designing an Interdisciplinary Educational Program to Support Transportation Workforce Development. In Transportation Research Record: Journal of the Transportation Research Board, No. 1812, TRB, National Research Council, Washington, D.C., 2002, p.143.

<sup>7</sup> TRB Special Report 275 (2003). “The Workforce Challenge: Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies.” Transportation Research Board of the National Academies, Washington, D.C., p. 5.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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Experts have long noted a need for change in the way that engineering is taught. Technological advances and rapid access to information led Zimpher to assert that “helping learners to know how to access information, evaluate it critically, and use it to solve problems” will be the role of education in the information age.<sup>8</sup> Additionally, understanding how people learn has become the focus of many studies. The National Research Council concludes that “when students learn [subject matter] in only a limited context, they often miss seeing the applicability of that information to solving novel problems. . . . Faculty can help students apply subject matter to other contexts by engaging them in learning experiences that draw directly upon real-world applications. . . . Problem-based learning . . . create(s) opportunities for students to engage in practices similar to those of experts.”<sup>9</sup> Active, problem-based learning, which poses generative open-ended questions in an environment where students actively participate in their own learning processes, is being used in engineering classrooms in the proposing institutions and across the nation, and results are encouraging.<sup>10</sup>

As an example of this approach, at the University of Idaho’s annual Traffic Signal Summer Workshop, students developed essential traffic engineering competencies in a hands-on learning environment. Seven years of student feedback from these workshops has been overwhelmingly positive, indicating both improved technical knowledge and a heightened interest in transportation engineering as a career.<sup>11</sup> Learning assessments show that these learner-centered teaching methods yield superior outcomes in “short-term mastery, long-term retention, depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, (and) level of confidence in knowledge or skills.”<sup>12</sup>

Agrawal and Dill surveyed over 1800 civil engineering undergraduates examining the factors that led students to choose transportation as their specialty. Their results show that what students learned in the transportation courses and the quality of the faculty are the two most important educational factors in determining their choice. In addition, the researchers conclude that the opportunity for internships, which give students the chance to interact directly with professionals in the field, is another leading factor in choosing transportation.<sup>13</sup> The studies above point to direct solutions that educational institutions, in partnership with State DOTs and industry, can undertake to attract students to the field of transportation engineering.

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<sup>8</sup> National Research Council. Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering, and Mathematics. National Research Council, 2003.

[http://books.nap.edu/openbook.php?record\\_id=10024&page=25](http://books.nap.edu/openbook.php?record_id=10024&page=25). Accessed August 24, 2007.

<sup>9</sup> Ibid. p. 22.

<sup>10</sup> [http://www4.ncsu.edu/unity/lockers/users/f/felder/public/student\\_centered.html](http://www4.ncsu.edu/unity/lockers/users/f/felder/public/student_centered.html). Accessed August 24, 2007.

<sup>11</sup> Kyte, M., A. Abdel-Rahim and M. Lines. Traffic Signal Operations Education through Hands-on Experience: Lessons Learned from a Workshop Prototype. In Transportation Research Record: Journal of the Transportation Research Board, No.1848, TRB, National Research Council, Washington, D.C., 2003, pp. 50-56.

<sup>12</sup> <http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Student-Centered.html>. Accessed August 24, 2007.

<sup>13</sup> Agrawal, A.W. and Jennifer Dill. To Be a Transportation Engineer or Not? How Civil Engineering Students Choose a Specialization. Submitted for Presentation at the 87th Annual Meeting of the Transportation Research Board, Washington, D.C., 2007.

### 1.3 What the Project Team Did

We completed a 54-month schedule in which four transportation courses were developed, deployed, and assessed. The pedagogical paradigms embedded in the process-education philosophy of Beyerlein, Apple, and others<sup>14</sup> and the learning outcomes based curriculum design approach of Wiggins and McTighe<sup>15</sup> served as the basis for this work. The four activity-based learning transportation courses that were developed include:

- Traffic Signal Systems Operations and Design (University of Idaho)
- Understanding and Communicating Multi-Modal Transportation Data (Portland State University)
- Introduction to Freight Transportation (University of Washington)
- Rural Highway Design and Safety (University of Alaska)

Our accomplishments can be summarized in three categories:

- the *process* that was followed in developing the materials (described in chapter 2)
- the *materials* that were developed and disseminated (described in chapter 3)
- the courses that were *delivered* and *assessed* using these materials (described in chapters 3 and 4)

#### Process

The development of the course materials consisted of five steps including an analysis of the course audience, a definition of the course environment, the design of the course itself, the planning of the individual units, and the design of each of the activities. Before the activities were designed, we established the learning outcomes and the knowledge tables: what we wanted the students to know and be able to do as a result of completing this course. This process and the resulting information are included in the course design documents developed for each course. The full course design documents are published separately and are available on the project web site (See Appendix A).

#### Materials

The curricula consist of a set of activities that generate an active learning environment in which students build their own knowledge base for a particular course topic. The materials developed to support this active learning environment include an activity book, a facilitation guide for instructors, and a set of supplementary material for use by students. Two of the activity books have been published by Pacific Crest, one of the leading academic and publishing organizations for process and activity-based education. All of the books and supporting materials are available on the project web site.

Four workshops were conducted as part of this project to facilitate the development of the materials and to disseminate the work that was completed at key times during the project.

- Development of team skills in the course design process for activity based learning, Moscow, Idaho, June 2010

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<sup>14</sup> Steven Beyerlein, Carol Holmes, and Daniel Apple, "Faculty Guidebook", Pacific Crest, Lisle, IL, 2007.

<sup>15</sup> Grant Wiggins and Jay McTighe, "Understanding by Design, Expanded 2<sup>nd</sup> Edition", ASCD, 2005.

## **Development, Deployment, and Assessment of Activity-Based Transportation Courses**

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- Public presentation of interim project results and example curricula during the set of “Sunday workshops” held as part of the annual meeting of the Transportation Research Board, Washington, D.C., January 2011
- Presentation of preliminary project results and example curricula as part of the Pacific Northwest section of the American Society of Engineering Education, Portland, Oregon, March 2012
- Final peer review and dissemination workshop to review the materials and to promote the use of activity-based learning amongst university faculty, Seattle, Washington, August 2012

### **Delivery and Assessment**

The four courses were delivered a total of fourteen times during the project to university students in the Pacific Northwest. One course was delivered by distance to students at the University of Idaho, the University of Washington, and Portland State University. As part of each course delivery, an assessment of student learning and of the materials themselves was completed.

### **1.4 What This Report Covers**

This report includes five chapters including this first chapter. Chapter 2 describes the approach that we took and the process we followed to achieve the project objectives. Chapter 3 describes the products and deliverables from this project. Chapter 4 provides an assessment and evaluation of the work that we completed. Chapter 5 describes the findings, conclusions, and lessons learned from this work. The appendices include some of the key documents resulting from this project including the course design documents, the activity books for each of the four courses, and the supplemental information available for students and instructors who use this material.



## CHAPTER 2. APPROACH AND PROCESS

This chapter describes the approach that we took in designing the course materials and the process that we followed in the deployment and testing of the materials. The first section of the chapter describes the overview and timeline of this process. The second section describes the course design process and the resulting course design document that was used as a template in the development of each of the four courses. The third section describes the deployment and assessment schedule of the four sets of curriculum materials that make up each of the courses.

The course design process includes all planning activities that provide the framework and underlying ideas for the development of the curriculum materials. The initial step in the process was the selection of the titles of each of the courses. This selection reflected the subject matter expertise and interests of each of the university teams, as well as an assessment of the need for new or revised transportation courses that emphasized a more active learning approach in these areas. The course titles are listed below:

- Traffic Signal Systems Operations and Design (University of Idaho)
- Understanding and Communicating Multi-Modal Transportation Data (Portland State University)
- Introduction to Freight Transportation (University of Washington)
- Rural Highway Design and Safety (University of Alaska)

### 2.1 Overview and Timeline

Figure 1 shows an overview of the work completed by the project team. Nine team meetings were held between 2009 and 2012 in which ideas and documents were developed and reviewed. The course planning and design work was started at the University of Idaho in fall 2008. The three other teams used this prototype experience to assist them in their own course design process, beginning in January 2009 for the Portland State University team and in June 2010 for the University of Washington and University of Alaska teams. Course revisions continued throughout the project as each team delivered, tested, and evaluated the course materials. Figure 1 also shows the four workshops that were held to review ideas and to solicit feedback, including a public review of the materials as part of the 2011 annual meeting of the Transportation Research Board and a final peer review of the course materials in August 2012.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

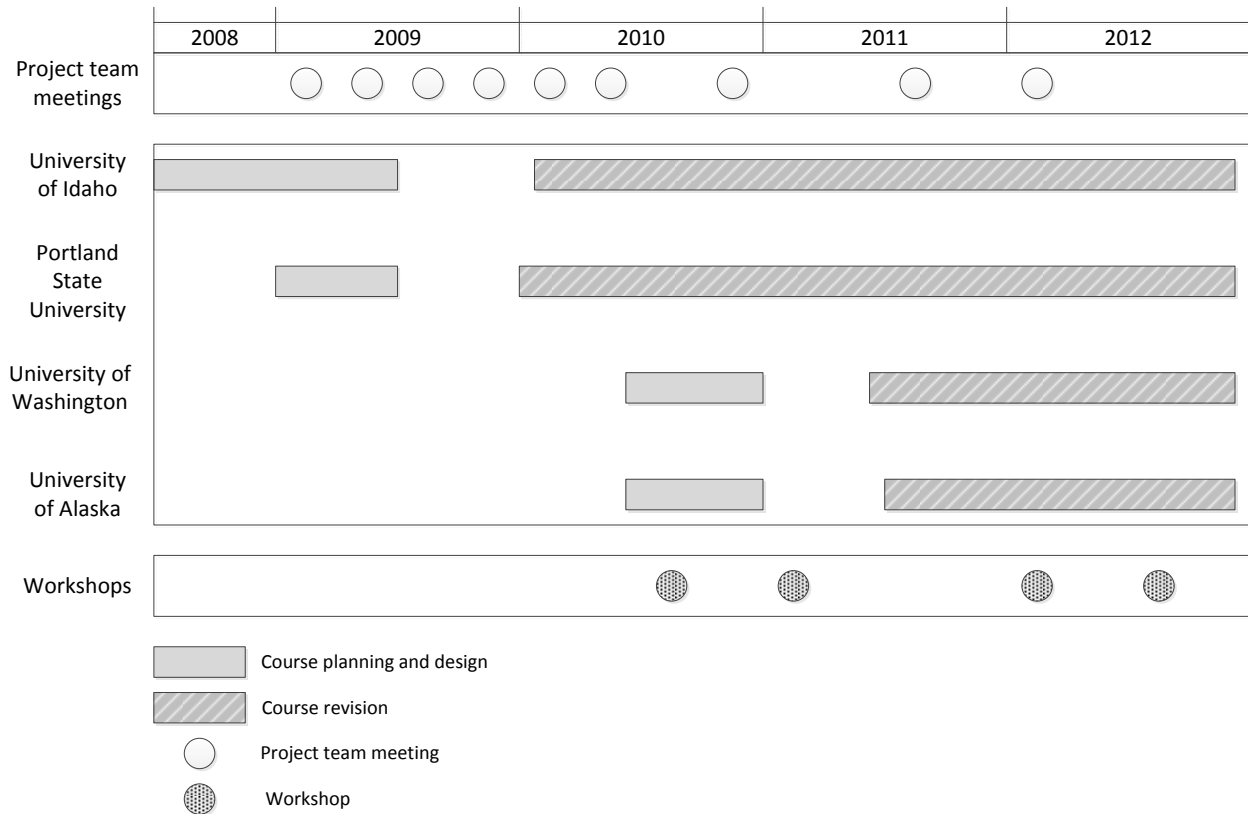


Figure 1. Project timeline: team meetings and workshops

### 2.2 Course Design Process

The course design process followed in this project is based on the work of Apple, Beyerlein, and others<sup>16</sup> and Wiggins and McTighe<sup>17</sup>. Both groups emphasize the importance of student-centered learning in which students build their own knowledge base through their active participation in the learning process. Further, both groups emphasize the importance of formative assessment, in which students continually receive feedback designed to help them clarify and solidify what they have learned in a timely manner.

The course design process developed for this project, and summarized in Figure 2, consists of five steps:

1. Analysis of the potential audience, the behaviors that the course will attempt to promote, and the professional roles that are desired for the students to assume
2. Determination of the desired course environment, including the duration of the course, the expected enrollments, and the delivery format
3. Course design, including the vision for the course, the identification of the learning outcomes and knowledge table, and the assessment and evaluation process to be used
4. Planning of the course units, including the course outline, major sections, and the sequence of the activities

<sup>16</sup> Steven Beyerlein, Carol Holmes, and Daniel Apple, "Faculty Guidebook", Pacific Crest, Lisle, IL, 2007.

<sup>17</sup> Grant Wiggins and Jay McTighe, "Understanding by Design, Expanded 2<sup>nd</sup> Edition", ASCD, 2005.

5. The design of the individual activities, including the format of the template that would be used in this design

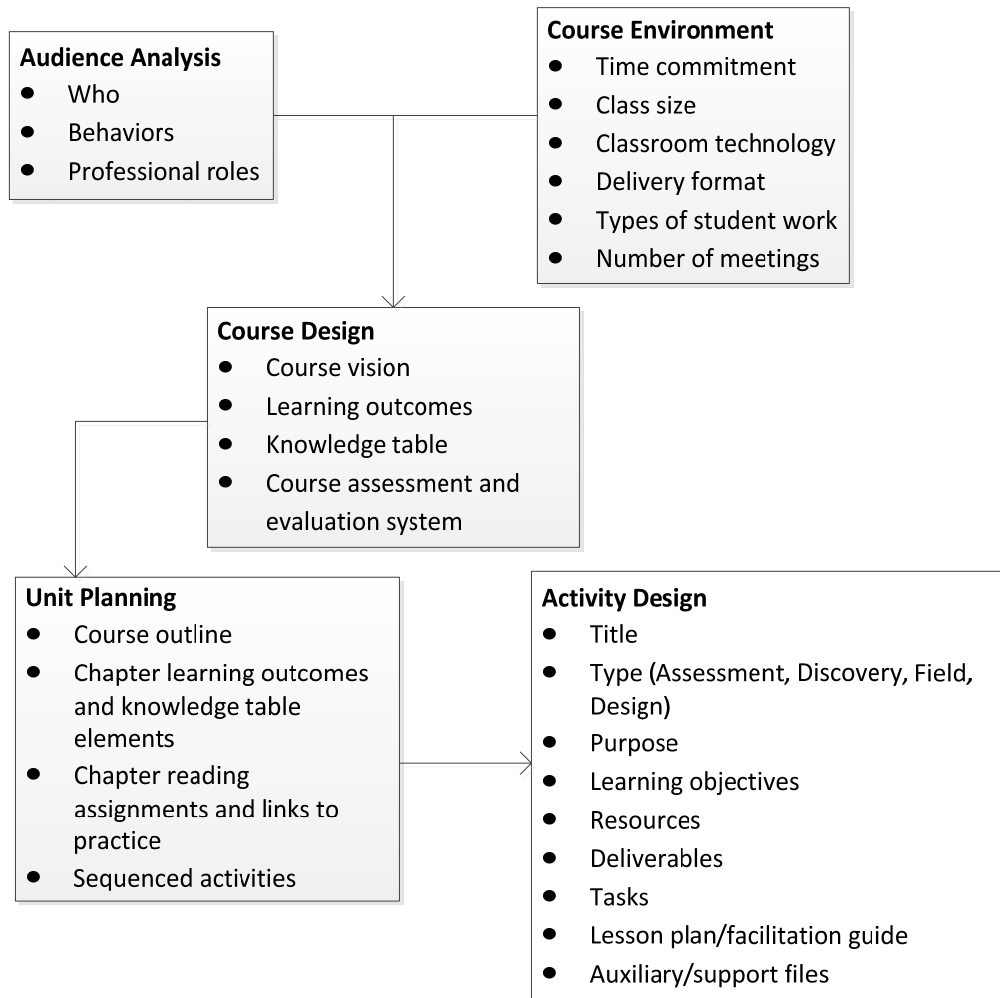


Figure 2. Course design process

The course design documents based on this process, and developed for each of the four courses, are published separately and available on the project web site (See Appendix A in this report for the links to this web site).

### Audience Analysis

An audience analysis ensures that a course is designed to serve the intended population of students. This analysis also includes visualization of long-term behaviors that a course is intended to promote, beyond the end of the course and into professional practice. The audience analysis should capture who the potential students are, and what they know. This analysis includes likely distribution in age, education, experience, physical location, and technical background of the students. It is helpful to identify several professional roles that students can identify with and in which they can grow throughout the course.

### **Course Environment**

Physical and temporal constraints surrounding delivery of the course need to be established before significant progress can be made in course design. This includes the location(s) of faculty and students, the number and type of contact hours, expectations of work outside of class, and the level of interaction between participants outside of formal class meeting times.

### **Course Design<sup>18</sup>**

The course design includes four critical components: the vision for the course, the learning outcomes that the students will meet, the knowledge table that forms the basis for what students will learn, and the manner in which student performance will be assessed.

#### *Course Vision*

It is important to articulate an overall theme for the course that briefly describes the course in a way that can promote brainstorming about course content, course activities, faculty preparation, and marketing to potential students. Ideally the vision should connect cognitive, social, and affective dimensions of the course. The vision is not static, it can be strengthened as learning outcomes are articulated, course knowledge is classified, and learning activities are scoped and sequenced. The vision serves to align and validate course components and delivery strategies. To create an effective course vision it is helpful to isolate a phrase that will resonate with important course stakeholders and offers insight about what is expected to be unique and exciting about the course. The course vision is the source of various themes that can unify week-by-week course design.

#### *Learning Outcomes*

Learner performance is more likely to improve if one is able to precisely define what is to be achieved along with how this performance can be documented at the end of a learning experience. The number of learning outcomes for a course should be small enough so individual outcomes can be revisited several times throughout the course and the set of learning outcomes for a course should be varied enough to make learning activities realistic. For a typical 3-credit college course, a good target is ten to twelve course outcomes. While the types of learning outcomes will be defined shortly, for a typical engineering course the number of competency outcomes is often equal to the total number of movement, experience, and integrated performance outcomes.

Learning outcomes should be phrased such that they describe student behaviors that are developed by the end of the course. Learning outcomes provide a vector for development in relevant learning activities. In contrast, learning objectives for each learning activity are intermediate milestones that can be achieved at the end of the learning activity.

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<sup>18</sup> The material in this section is adapted from "Learning Outcomes", Steven Beyerlein, Denny Davis, and Daniel Apple, pages 245-248, in "Faculty Guidebook", Steven Beyerlein, Carol Holmes, and Daniel Apple, Pacific Crest, Lisle, IL, 2007.

It is helpful to separate different types of learning outcomes with respect to who is performing the outcome and the nature of the outcome (see Figure 3). The common outcomes in higher education include competencies, movement, experiences, accomplishments, and integrated performance. Each type of outcome is best suited to different educational methods and requires collecting different evidence to demonstrate that the outcome has been achieved.

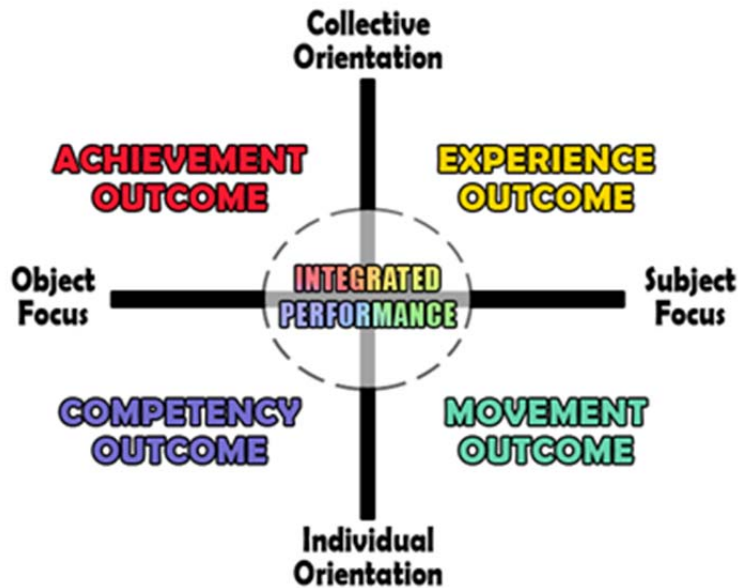


Figure 3. Types of Learning Outcomes

*Competency outcomes* are tasks that learners must perform at a prescribed level in a specific context. Competency outcomes typically probe lower to mid-levels in Bloom’s taxonomy<sup>19</sup> (i.e. remember, understand, apply, or analyze). Competency outcomes are snapshots of what learners can do at a specific point in time, and they are relatively easy to measure. Common learning activities that support competency outcomes are guided discovery and active learning. To promote long-term retention of competency outcomes, it is advisable to target at Bloom’s level of “apply” or above. Two examples of competency outcomes include:

1. Find all positive real roots of a second-order polynomial using the quadratic formula
2. Use a decision matrix to defend a solution from among multiple alternatives, customer requirements, and resource limitations

*Movement outcomes* focus on personal and professional development. They prescribe a desired direction and magnitude of growth that extend well beyond the present capabilities of all learners. Movement outcomes require samplings over time to establish whether real growth as occurred. Common learning activities that support movement outcomes are peer and self-assessments, logbooks, and self-growth papers. Two examples of movement outcomes include:

1. Translate word problems in to symbolic equations with greater speed and accuracy

<sup>19</sup> Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives: Complete edition*, New York : Longman.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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2. Manage project knowledge, resources, and the work environment to produce a more effective design product in a timely manner, and within budget

*Experience outcomes* capture changes in attitudes, values and behaviors that result from life-changing experience. They should reveal awareness and critical analysis of the causes and impacts of personal changes in the learner. Common learning activities that support experience outcomes are team projects, seminars led by guest facilitators, and field trips. Common measurement tools for experience outcomes are personal interviews, focus groups, and reflective writing. Two examples of experience outcomes include:

1. Serve as a tutor once a week throughout a semester in a math laboratory at a local high school, advancing your confidence in learning mathematics
2. Gain appreciation of professional practice through interactions with clients, mentors, team members, and support staff in a year-long product development project, documenting issues and discoveries in a journal that illustrates formation of a personal design philosophy

*Accomplishment outcomes* are recognized through outside affirmation from other faculty, alumni, or practitioners in the field. They are worthy of mention on a resume. Common learning activities that support accomplishment outcomes are project work, service learning, and formal presentations. Common measurement tools for accomplishment outcomes are testimonials, awards, and recommendations. Two examples of accomplishment outcomes include:

1. Place in the top 10% at a student math league competition
2. Produce a design product that impresses a client, your peers, and the general public at a year-end design show and wins an award while at the same time meeting key functional performance specifications so that the product is used by the client

*Integrated performance outcomes* require extension and transfer of knowledge, skills, and perspectives in response to challenging situations which are new and meaningful to the learner. Integrated performance outcomes typically probe upper-levels of Bloom's taxonomy (i.e. analyze, evaluate, or create). Common learning activities that support integrated performance outcomes are role playing, creative performances, and capstone projects. Common measurement tools for integrated performance outcomes are formal performance appraisals and feedback from an external review. Two examples integrated performance outcomes include:

1. Use mathematical skills developed in this course to formulate, analyze, and report quantitative results related to a scientific experiment in your lab course
2. Display professionalism in forming client relationships, assuming team responsibilities, achieving consensus, fulfilling commitments, applying prior knowledge, and conducting self-directed learning in a capstone project course

Establishing a strong set of learning outcomes for a course is an iterative process. Time should be spent early on to create a fairly complete initial draft that encompasses all types of relevant outcomes for the course. Another way to develop the set of course outcomes is to inventory a large list of learning objectives, find a logical groupings of objectives, determine the highest

level of performance desired within each grouping, and write an outcome statement that defines this level of performance.

### *Knowledge table*

A knowledge table identifies the content you want students to know and how students can most effectively explore this knowledge. The knowledge table surfaces key concepts, identifies important processes and tools, suggests important contexts for learning, and reinforces important long term behaviors. Five types of knowledge should be included in the knowledge table, including concepts, processes, tools, contexts, and ways of being.

- *Concepts* are ideas that connect a set of relationships. Concepts are representational and abstract. Concepts are best introduced with definitions, pictorial representations, and interactive learning objects.
- *Processes* are a sequence of steps, events, or activities that result in a change or that produce something over a period of time. Processes are active and continuous. Processes are best introduced through methodologies that guide users through a sequence of steps with quality standards. Processes focus on actual performance, not just understanding what to do.
- *Tools* are any device, implement, instrument, or utensil that serves as a resource to accomplish a task. Tools can be in paper form (templates), electronic form (software/simulation), or physical form (laboratory hardware). Tool knowledge includes selection and use of the tool, not just understanding its features or its typical use.
- *Contexts* are the whole situation, background, or relevant conditions surrounding learning. Contextual knowledge is needed for experience outcomes. Contextual knowledge focuses on adaptation to varied conditions, not changes in basic processes.
- *Ways of being* are sets of behaviors, actions, and language associated with a particular discipline, knowledge area, or culture. Ways of being reflect preferences and tacit assumptions, not understanding of concepts or processes.

Construction of the knowledge table is also an iterative process. Even after the initial knowledge table is completed, it should be revisited as more details at the weekly and activity level are completed to capture important decisions about course content. Issues exposed in the generation of a knowledge table include the following:

1. If there is excessive ambiguity in the distinctions among the five forms of knowledge within a map, e.g., by overlapping concepts with processes, learning activities may also lack appropriate focus
2. If the descriptions and details used to represent the five forms of knowledge within a knowledge map are disjointed, e.g., lacking in integration or parallelism, multiple problems in learning and assessing performance are likely
3. If there is not enough detailing or complexity in how the forms in the map are represented, learners may not fully recognize relevant exemplars or models, and educators may find it difficult to provide clear assessments

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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### *Course Assessment and Evaluation system*

There are many ways to provide assessment and collect evaluation. Care should be taken to match the tool with the type of outcome being measured. For each outcome it is beneficial to use multiple tools to improve accuracy of the measurement. It is also more efficient to select tools cut across multiple outcomes in order to minimize the number of measurements being accounted.

It is useful for students to have a guideline for expectations on assignments. For most evaluation tools a lot can be learned and communicated through use of a rubric. The rubric should divide the task in to several categories or components. Then descriptions of what performance in those categories looks like at various levels should be added so the students have an idea of what is expected of them.

### **Unit Planning**

A course usually consists of several parts or units. Before fleshing out individual activities it is important to identify the set of learning activities intended to support each unit within the course. Unit planning often starts with the development of the course outline and syllabus. This is followed by a sequenced set of reading assignments, each designed to provide the student with an initial base of knowledge in a particular area of the course. Lastly, a list of sequenced activities is developed that includes the targeted course outcomes and the elements of the knowledge table.

### **Activity Design**

The activity is the most fundamental unit of the course. The activity defines a set of actions that the student will undertake to accomplish a specific learning outcome and develop a given base of knowledge. The design of each activity is based on a template that is used to ensure that expectations and processes will be clearly defined for the students. The following elements are included in the activity design template used for this project.

- The *Purpose* lets the students know what the activity is about and why it is worth doing.
- The *Learning Outcomes* describe what students will know or be able to do when they have completed the activity.
- The *Resources* identify what they will need to complete the activity.
- The *Deliverables* describe what students are expected to produce.
- The *Critical Thinking Questions* provide students with a chance to deeply and thoughtfully consider what they learned.
- The *Information* provides additional ideas or notes that will help them complete the activity.
- The *Tasks* list the specific steps that they will need to follow.

To assist instructors not involved in the development process in using the curricula, a facilitation guide was prepared. This guide consists of a set of notes that an instructor “takes into the classroom” to guide and facilitate the work of the students. The template used to develop the guide includes an overview of how to use the activity, options for its use, how to



prepare for the activity, what supplemental materials might be available, a script for conducting the activity, solutions to the questions and problems assigned, and a set of other useful notes.

### 2.3 Deployment and Assessment Schedule

This section of the report describes the schedule for the deployment and assessment of the curriculum materials for each of the four courses developed. Figure 4 shows the timeline for the delivery of the four courses, and how the delivery of the courses was related to the course design process. The four courses were delivered a total of fourteen times between 2009 and 2012. The points at which the courses were assessed are also shown.

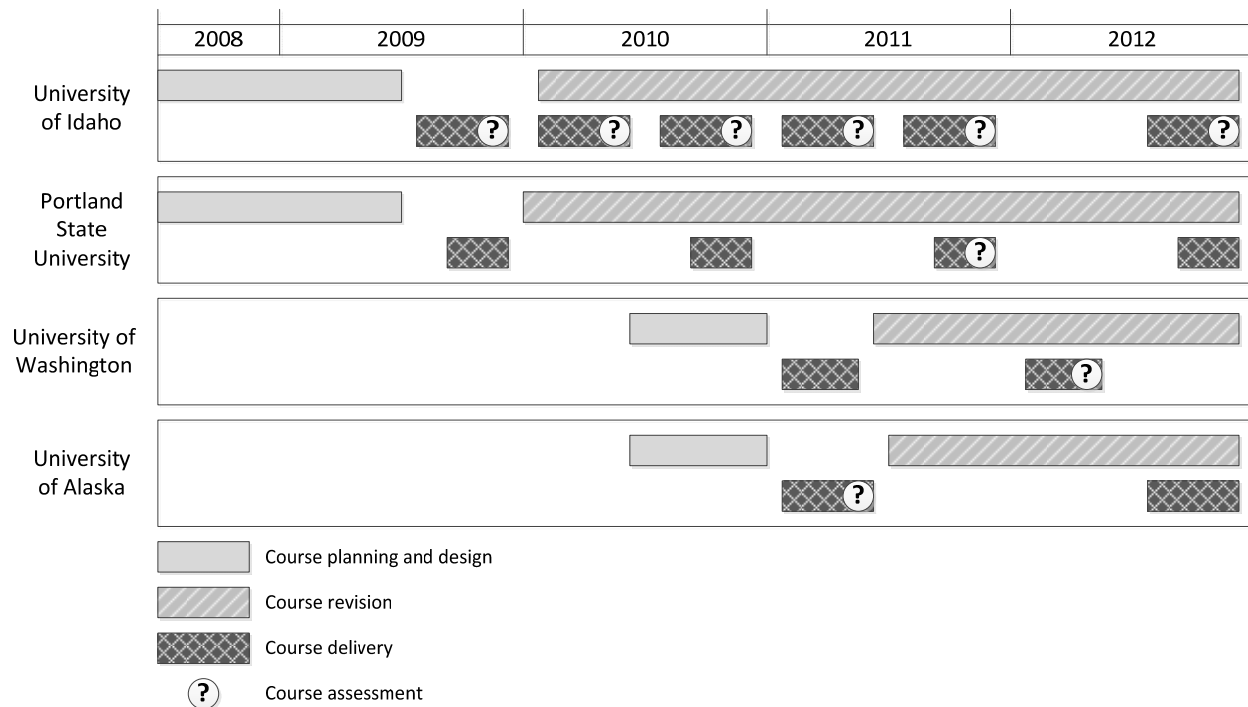


Figure 4. Course delivery periods

The courses were delivered to a total of 195 students during this period, as shown in Table 1.

- The University of Idaho course was delivered a total of six times during the project (between 2009 and 2012) to 101 students. In spring 2011, the class was delivered via live video and included two students from the University of Washington, seven students from Portland State University, one student from Washington State University, and five students from the University of Idaho.
- The Portland State University course was delivered a total of four times during the project (between 2009 and 2012) to 47 first-year transportation graduate students.
- The University of Washington course was delivered twice during the project (between 2009 and 2012) to a total of 27 students. Three types of students attended the classes: civil engineering students interested in freight research, civil engineering students in need of credits for graduation, and non-engineering students (e.g. students within public policy, marine affairs, and other related subjects) interested in the course content.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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- The University of Alaska course was delivered a total of two times during the project (between 2009 and 2012) to a total of 20 students.

**Table 1. Course delivery data**

| Course delivery date | Number of students  |                           |                          |                      |
|----------------------|---------------------|---------------------------|--------------------------|----------------------|
|                      | University of Idaho | Portland State University | University of Washington | University of Alaska |
| Fall 2009            | 17                  | 12                        | -                        | -                    |
| Spring 2010          | 6                   | -                         | -                        | -                    |
| Fall 2010            | 22                  | 12                        | -                        | -                    |
| Spring 2011          | 15                  |                           | -                        | 10                   |
| Fall 2011            | 20                  | 12                        | 14                       | 10                   |
| Fall 2012            | 21                  | 11                        | 13                       | -                    |

## CHAPTER 3. PRODUCTS AND DELIVERABLES

This chapter describes the activity books, facilitation guides, and other supporting materials for the four courses that were developed as part of this project. This material is summarized in Table 2 and described in more detail in the remainder of this chapter.

**Table 2. Products resulting from this project**

| Item  | University of Idaho  | Portland State University  | University of Washington   | University of Alaska  |
|---|--|--|--|---|
| Course title                                    | Traffic Signal Systems Operations and Control                          | Understanding and Communicating Multimodal Transportation Data       | Introduction to Transportation Freight   | Rural Highway Design and Safety   |
| Web site  | <a href="http://trafficsignalsystems.com">trafficsignalsystems.com</a> | <a href="http://transportation-data.com">transportation-data.com</a> | <a href="http://freight-transportation-education.com">freight-transportation-education.com</a> | <a href="http://www.ruralhighwaydesign.com/">http://www.ruralhighwaydesign.com/</a> |
| Activity book                                   | 10 chapters<br>63 activities   | 6 chapters<br>39 activities<br>6 special topic activities            | 7 units<br>10 activities<br>16 readings  | 8 chapters<br>18 activities   |
| Supplemental files for students and instructors | Word, Excel, and PowerPoint files, and movie files                     | Excel, PDF, and other files  | Excel, Word, and PDF files   | PDF, Excel and Word files   |

### 3.1 University of Idaho Course

The University of Idaho developed a design-oriented course titled “Traffic Signal Systems Operations and Design”. The course is intended to help university civil engineering students and practicing traffic engineers to better understand how isolated actuated traffic control systems work and to provide both groups with the opportunity to complete a signal timing design for an isolated intersection. The materials are intended for use in either a one semester or one quarter course at the senior or graduate level. The book can also be used by professionals in a self-study mode.

A web site has been established from which all course materials can be accessed (see Table 2 for URL information and Figure 5 for a screenshot of the web site). A companion web site for students (Figure 6) provides all required resources for students, references, and errata. An instructor resources site (Figure 7) includes the facilitation plans to assist instructors in preparing for and conducting the activities; this site also includes errata, feedback forms, and references. An electronic flipbook (see Figure 8) allows potential users to browse through the complete activity book.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

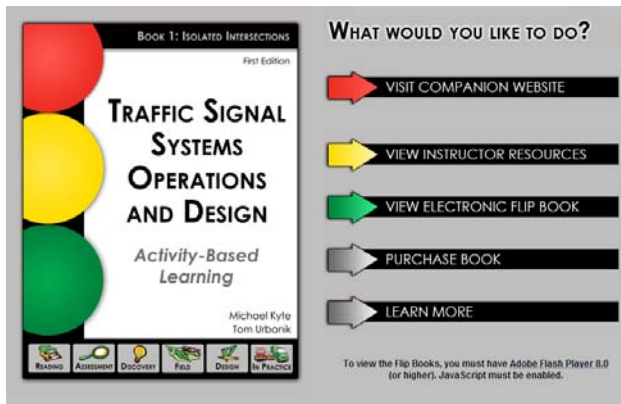


Figure 5. Course materials web site

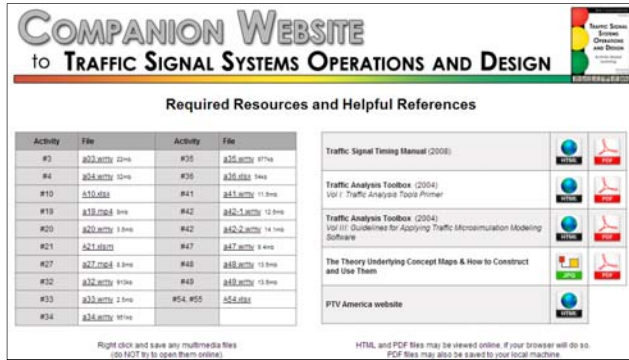


Figure 6. Companion web site



Figure 7. Instructor resources web site



Figure 8. Electronic flip book

The activity book is divided into ten chapters. The first four chapters (see Figure 9) provide a base level of knowledge on traffic signal systems. Chapters 5 through 9 address specific system components, providing first an understanding of how these components function and second how to design them. Finally, Chapter 10 integrates the components together into a final design in which students prepare a report and make a presentation covering their work.

The organization of the activity book, including the ten chapters and 63 activities are listed in Table 3 and Table 4. The activities are categorized into five groups: readings, assessments, discovery, field, design, and in-practice.

Most chapters have a similar structure. Each chapter begins with a reading that provides important information on the topics covered in the chapter. A series of activities follow, each providing hands-on experiences with the chapter topic.

- Assessment activities give students the chance to test and apply what they learned in the reading
- Discovery activities provide students with the opportunity to discover new factors or perspectives about the chapter topic by observing animations, collecting or analyzing data, or making calculations
- Field activities allow students to explore traffic flow and control conditions directly in the field and connect their field observations with the theory that they learned in other activities

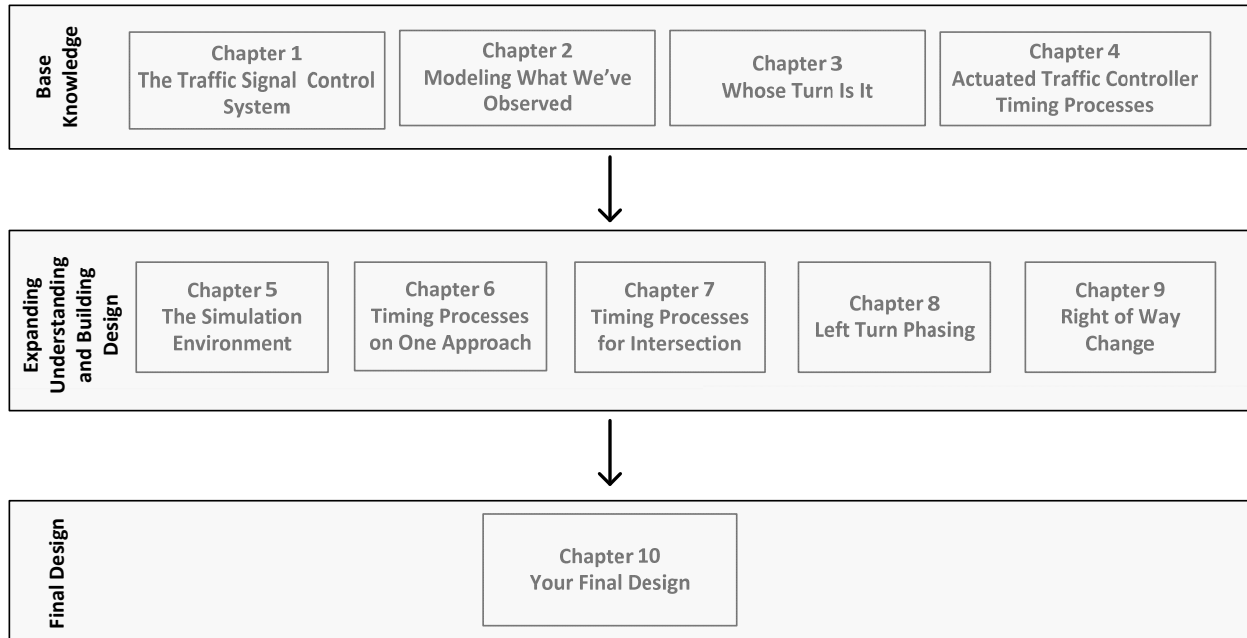


Figure 9. Organization of book

Each chapter concludes with:

- A design activity in which students will determine one component of their design and evaluate its performance
- An In Practice activity in which students compare your design component with recommended practice from the Traffic Signal Timing Manual

Each activity is based on a consistent format:

- The *Purpose* lets students know what the activity is about and why it is worth doing
- The *Learning Outcomes* describe what they will know or be able to do when they have completed the activity
- The *Resources* identify what they will need as they complete the activity
- The *Deliverables* describe what they are expected to produce
- The *Critical Thinking Questions* provide them with a chance to deeply and thoughtfully consider what they learned
- The *Information* provides additional ideas or notes that will help them complete the activity
- The *Tasks* list the specific steps that they will need to follow

## Development, Deployment, and Assessment of Activity-Based Transportation Courses


**Table 3. Activities for Traffic Signal Systems Operations and Design Course**

| Chapter | Activity #   | Activity name   | Activity type |
|---------|--|---|---------------|
| 1       | <b>The Traffic Signal Control System: Its Pieces and How They Fit Together</b> |   |               |
|         | 1  | Exploring the system and providing a framework                          | Reading       |
|         | 2  | What do you think you know about traffic signal systems?                | Assessment    |
|         | 3  | Exploring the system: driving along an arterial and noting what you see | Discovery     |
|         | 4  | Learning to see: the simulation environment in which we will work       | Discovery     |
|         | 5  | Working together – team building for effective learning and design      | Discovery     |
|         | 6  | Activity #5: Team agreement   | Design        |
|         | 7  | Introduction to the Signal Timing Manual                                | In Practice   |
| 2       | <b>Modeling What We've Observed</b>  |   |               |
|         | 8  | Modeling traffic flow at signalized intersections                       | Reading       |
|         | 9  | What do you know about queuing systems?                                 | Assessment    |
|         | 10   | Using high resolution field data to visualize traffic flow              | Discovery     |
|         | 11   | From model to real world: field observations                            | Field         |
|         | 12   | Basic operational principles  | In Practice   |
| 3       | <b>Whose Turn Is It: Phasing, Rings, and Barriers</b>                          |   |               |
|         | 13   | Phasing, rings, and barriers – an introduction                          | Reading       |
|         | 14   | What do you know about phasing and ring barrier diagrams                | Assessment    |
|         | 15   | Verifying ring barrier operation in the field                           | Field         |
|         | 16   | Link to Practice #3: Phasing, rings, and barriers                       | In Practice   |
| 4       | <b>Actuated Traffic Controller Timing Processes</b>                            |   |               |
|         | 17   | Controller timing processes   | Reading       |
|         | 18   | What do you know about controller operations                            | Assessment    |
|         | 19   | The ASC/3 traffic controller  | Discovery     |
|         | 20   | How a traffic phase times and terminates                                | Discovery     |
|         | 21   | Exploring a controller emulator   | Discovery     |
|         | 22   | Constructing a traffic control process diagram                          | Discovery     |
|         | 23   | Inferring signal timing parameter values                                | Field         |
|         | 24   | Signal timing parameters  | In Practice   |
| 5       | <b>The Simulation Environment: Learning to See a Traffic Signal System</b>     |   |               |
|         | 25   | Microsimulation models and the traffic control system                   | Reading       |
|         | 26   | What do you know about simulation models                                | Assessment    |
|         | 27   | The VISSIM simulation model – learning your way around                  | Discovery     |
|         | 28   | Building a simulation model network Design                              | Design        |
|         | 29   | Traffic analysis tools  | In Practice   |

**Table 4. Activities for Traffic Signal Systems Operations and Design Course (continued)**

|    |   |   |             |
|----|---|---|-------------|
| 6  | <b>Timing Processes on One Approach</b>                     |   |             |
|    | 30  | Considering minimum green time, passage time, and detection zone length                                   | Reading     |
|    | 31  | What do you know about detection zone length and passage time?  | Assessment  |
|    | 32  | Relating the length of the detection zone to the duration of the green indication                         | Discovery   |
|    | 33  | Determining the length of the minimum green time  | Discovery   |
|    | 34  | Understanding the variation of vehicle headways in a departing queue                                      | Discovery   |
|    | 35  | Relating headway to unoccupancy time and vehicle extension time   | Discovery   |
|    | 36  | Determining the maximum allowable headway   | Design      |
|    | 37  | Determining passage time and minimum green time   | Design      |
|    | 38  | Actuated traffic control processes  | In Practice |
| 7  | <b>Timing Processes for the Intersection</b>                |   |             |
|    | 39  | Maximum green time, cycle length, and delay   | Reading     |
|    | 40  | What do you know about maximum green time, cycle length, and delay?                                       | Assessment  |
|    | 41  | Determining the effect of the minor street vehicle extension time on intersection operations              | Discovery   |
|    | 42  | Determining the effect of the maximum green time on intersection operations                               | Discovery   |
|    | 43  | Setting the maximum green time for all approaches of an intersection                                      | Design      |
|    | 44  | Maximum green time  | In Practice |
| 8  | <b>Left Turn Phasing – Permitted, Protected, or Both?</b>   |   |             |
|    | 45  | Left turn phasing   | Reading     |
|    | 46  | What do you know about left turn phasing?   | Assessment  |
|    | 47  | Permitted left turn operations  | Discovery   |
|    | 48  | Comparing permitted and protected left turn phasing   | Discovery   |
|    | 49  | Comparing protected/permitted and protected left turn phasing   | Discovery   |
|    | 50  | Analysis and design of left turn treatment  | Design      |
|    | 51  | Left turn phasing options   | In Practice |
| 9  | <b>Right of Way Change – Change and Clearance Intervals</b> |   |             |
|    | 52  | The theoretical basis of the yellow and all-red intervals   | Reading     |
|    | 53  | What do you know about yellow and red clearance intervals?  | Assessment  |
|    | 54  | Drivers responding to yellow and red indications  | Discovery   |
|    | 55  | Vehicle response to displays at end of green  | Field       |
|    | 56  | Determining the vehicle change and clearance intervals considering variability of vehicle approach speeds | Design      |
|    | 57  | Yellow and red clearance intervals  | In Practice |
| 10 | <b>Your Final Design – Putting It All Together</b>          |   |             |
|    | 58  | Integrating information, justifying choices, and communicating results                                    | Reading     |
|    | 59  | Assembling Information For Your Timing Plan Design  | Discovery   |
|    | 60  | What do you know about the signal timing design process: issues and themes                                | In Practice |
|    | 61  | Signal timing design process  | In Practice |
|    | 62  | Design report   | Design      |
|    | 63  | Design evaluations and assessments  | Design      |

Figure 10 shows excerpts from an example activity in which students learn about traffic flow using a high resolution data set that was collected in the field.

**ACTIVITY**  
**10** **Using High Resolution Field Data to Visualize Traffic Flow** 

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**PURPOSE**  
The purpose of this activity is to give you the opportunity to see how queuing system models relate to high resolution field data.

**LEARNING OBJECTIVES**

- Connect your observation of traffic flow at a signalized intersection with a model framework
- Represent and interpret queuing diagrams for a range of traffic flow and control conditions

**REQUIRED RESOURCE**

- Spreadsheet file: A10.xlsx

**DELIVERABLES**

- Prepare an Excel worksheet that includes the following information:
  - Tab 1: Title page with activity number and title, authors, and date completed
  - Tab 2: Original data
  - Tab 3: Time-space diagram plot with answers to questions from Task 2
  - Tab 4: Cumulative vehicle diagram plot
  - Tab 5: Uniform delay calculation
  - Tab 6: Summary and answers to Critical Thinking Questions

Figure 10. Excerpt from Activity #10

The facilitation guide provides instructors with information on how to conduct each activity. Figure 11 shows an excerpt of a solution provided in the facilitation guide for Activity #10.



## Using Activity #10: Using High Resolution Field Data to Visualize Traffic Flow (Discovery)

### Overview

The purpose of this activity is for students to see how the queuing models can represent real traffic flow conditions using data from the FHWA NGSIM project.

### Options for Use

This activity can be done either in class or as homework.

### Preparing for the Activity

- Determine whether you will conduct this activity during class or assign it as homework.
- Review the activity description and tasks, and review the NGSIM data set that students will use for the project.

### Supplementary Materials

- Slides (slides10.pptx)
- Excel data set for student use (a10.xlsx)
- Solution file (solution10.xlsx)

### Doing the Activity (Script)

The following script can be used along with the slides for this activity. The script and slides can be modified based on your needs and what you decide to emphasize for the activity.


| Slides  | Text  |
|---|---|
|  | <ul style="list-style-type: none"> <li>• So let's review for just a bit what we talked about yesterday and what you read and did in Activity #8 and Activity #9. We want to be able to represent traffic flow at a signalized intersection with queuing theory approach.</li> <li>• Now the specific queuing model that we use is called a D/D/1 model. Arrivals are deterministic (uniform, constant rate), service</li> </ul> |

Figure 11. Excerpt from facilitation guide, Activity #10

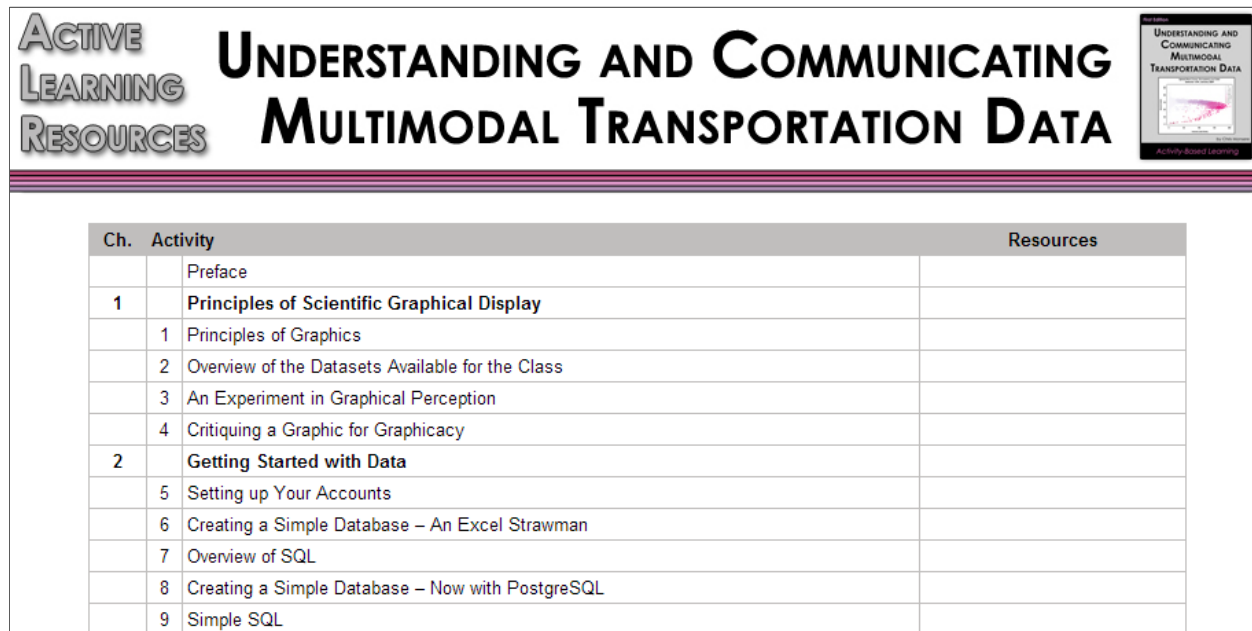
In addition, there are 15 video files showing various aspects of traffic flow and signal operations, and four Excel data files that students use to learn about real world traffic operations.

## 3.2 Portland State University Course

Portland State University developed a design-oriented course titled “Understanding and Communicating Transportation Data”. The course is intended to introduce students to appropriate research methods for using transportation data sets and communicating the results of their work to a broad audience.. It is intended to expose students to large, empirical data sets and give them fundamental tools for exploring and mining these data sets. Special emphasis is placed on selecting the appropriate graphic for the type of data. Basic concepts of

statistics are explored using these large data sets. Finally, students are introduced to using script-based analysis to automate many repetitive and complicated analysis procedures. It is intended primarily for a one quarter course at the graduate level. The book can also be used by professionals or others in a self-study mode.

A web site has been established from which all course materials can be accessed (see Table 2 for URL information and Figure 12 for a screenshot of the web site).



| Ch. | Activity   | Resources |
|-----|--|-----------|
|     | Preface  |           |
| 1   | <b>Principles of Scientific Graphical Display</b>  |           |
|     | 1 Principles of Graphics                           |           |
|     | 2 Overview of the Datasets Available for the Class |           |
|     | 3 An Experiment in Graphical Perception            |           |
|     | 4 Critiquing a Graphic for Graphicacy              |           |
| 2   | <b>Getting Started with Data</b>                   |           |
|     | 5 Setting up Your Accounts                         |           |
|     | 6 Creating a Simple Database – An Excel Strawman   |           |
|     | 7 Overview of SQL                                  |           |
|     | 8 Creating a Simple Database – Now with PostgreSQL |           |
|     | 9 Simple SQL                                       |           |

**Figure 12.** Course materials web site for Understanding and Communicating Multimodal Transportation Data course

The activity book is divided into six chapters. The activities are categorized into five types: participation, annotated code, peer assessment, short response, and discovery. These activities fit into six different chapters within the book:

1. Principles of scientific graphical display
2. Getting started with data
3. Introduction to R
4. Using graphics for exploratory data analysis
5. Data exploration for understanding
6. Putting it all together: an independent structured analysis

The 39 activities are listed in Table 5. These activities expose students to real transportation data sets increasing their comfort in interacting, exploring, analyzing, and explaining data related to transportation. The majority of the class activities took place in the computer lab with some traditional lectures. Materials utilized for the course included open source software such as (R, R Studio, and PostgreSQL). Textbooks were also utilized in the course (many of the activities in Chapter 4 use a textbook as a key reference). Data sets utilized within the course

were obtained via a regional data archive accessible to PSU students and faculty. These are available in either CSV format or a “dump” file of the PostgreSQL tables that could be loaded into the user’s installation.

**Table 5. Activities for Understanding and Communicating Multimodal Transportation Data course**

| Chapter                            | Activity #  | Activity name   |
|------------------------------------|---|---|
| 1                                  | Principles of Scientific Graphical Display                            |   |
|                                    | 1   | Principles of Graphics  |
|                                    | 2   | Overview of the Datasets Available for the Class                                      |
|                                    | 3   | An Experiment in Graphical Perception   |
| 2                                  | 4   | Critiquing a Graphic for Graphicacy   |
|                                    | Getting Started with Data   |   |
|                                    | 5   | Setting up Your Accounts  |
|                                    | 6   | Creating a Simple Database – An Excel Strawman  |
|                                    | 7   | Overview of SQL   |
| 3                                  | 8   | Creating a Simple Database – Now with PostgreSQL                                      |
|                                    | 9   | Simple SQL  |
|                                    | Introduction to R   |   |
|                                    | 10  | An Introduction to R and R Studio   |
|                                    | 11  | Setting Up R  |
|                                    | 12  | A Starting Point – Some Simple R  |
|                                    | 13  | Reading in Data Files   |
|                                    | 14  | R Plots   |
|                                    | 15  | Learning Some Simple Plotting Features of R   |
|                                    | 16  | Your First Advanced Plot  |
|                                    | 17  | Code Sharing  |
|                                    | 18  | Thinking like a Computer – Pseudo-coding and Functions                                |
|                                    | 19  | Write Your Own Function   |
|                                    | 20  | Connecting to the Class Database via RODBC and PostgreSQL Drivers                     |
| 4                                  | 21  | Using R with PostgreSQL   |
|                                    | 22  | Packages  |
|                                    | Using Graphics for Exploratory Data Analysis                          |   |
|                                    | 23  | Activity #23 Basic Charts for Single Discrete Variable                                |
|                                    | 24  | Exploring Single Discrete Variable Plots  |
|                                    | 25  | Recycling Code from the Keen Text   |
|                                    | 26  | Exploratory and Diagnostic Plots for the Distribution of a Single Continuous Variable |
|                                    | 27  | Interactive Review of Basic Statistics Using R  |
|                                    | 28  | Kernel Density Estimates and Histograms   |
|                                    | 29  | Working with Time in R  |
|                                    | 30  | Probability Distributions   |
|                                    | 31  | Diagnosing a Distribution   |
|                                    | 32  | One and Two Sample Tests  |
|                                    | 33  | Exploring Confidence Intervals and Simple Hypothesis Testing                          |
|                                    | 34  | An Application of Hypothesis Testing  |
|                                    | 35  | Depicting the Distribution Involving Discrete Variables                               |
|                                    | 36  | Introduction of Final Project Topics  |
|                                    | 5   | 37  |
| 38                                 |   | Advanced Multivariate Continuous Displays and Diagnostics                             |
| Data Exploration for Understanding |   |   |
| 39                                 |   | Activity #39 Introduction to Random Sampling  |
| 6                                  | 40  | Activity #40 Mining for Data Quality  |
|                                    | 41  | Activity #41 Which Method or Analysis Technique to Use                                |
|                                    | Chapter 6 Putting it All Together: An Independent Structured Analysis |   |
|                                    | Topic 1   | Assessing The Accessibility Of Trimet Bus Stops                                       |
|                                    | Topic 2   | Assessing Trimet Bus Headway Reliability  |
|                                    | Topic 3   | Bicycle Performance   |
|                                    | Topic 4   | Freeway Data and Incidents  |
|                                    | Topic 5   | Freeway Data and Weather  |
| Topic 6                            | WIM Data – Side By Side Loadings                                      |   |





Most chapters have a similar structure. The chapter begins with a short introduction and a list of the activities and the corresponding assessment category. The chapter then contains all of the activities and instruction notes.


Each activity is based on a consistent format. There is a brief introduction to the activity topic. The purpose, learning objective, required resources, and time allocated are clearly specified in the activity introduction. The tasks that students work through are then described in detail. Most activities include a sample R script that the students work through and answer questions throughout the activity. Figure 13 shows a sample of header files of one activity. At the conclusion of each activity, the required deliverables and assessment methods are provided. Figure 14 shows a sample on the end of the file which clearly specifies the required deliverable, the assessment method and a grading rubric.

## A STARTING POINT: SOME SIMPLE R

ACTIVITY  
**12**

We are going to do some simple things to learn about R. This will be a guided exercise – meaning that the instructor will demonstrate the steps on the screen while you follow along on your desktop.

|  |  |
|--|--|
|  <b>PURPOSE</b><br>The purpose of this activity is to give you the opportunity to become familiar with the R interface and syntax.                                       |  <b>LEARNING OBJECTIVE</b><br>To be able to use R. |
|  <b>REQUIRED RESOURCES</b> <ul style="list-style-type: none"><li>◦ R, R Studio</li><li>◦ Chapters 1 and 2 in <i>Introductory statistics with R</i> (Dalgaard)</li></ul> |  <b>TIME ALLOCATED</b><br><br>60 minutes in class |

**TASKS** 

*This activity begins assuming both R and R Studio are open. If not, please start them.*


Figure 13. Sample activity header

## DELIVERABLE


Annotated code – submit your R script to the Dropbox with the answers to the six questions. In your R code use comments to indicate your answers but make sure the R code that you modify to answer the questions can be run by the instructor to verify that it works. For example:

```
#Question 3 - The "hard" way would be to add each element of the vector
individually using the [] syntax. My code to do this would be

boarding[1]+boarding[2]+boarding[3]+boarding[4]+boarding[5]+boarding[6]
```



## ASSESSMENT



### Activity 12 Grading Rubric

|            | Excellent (10)  | Good (8)   | Poor (6)   | 0                     |
|------------|---|--|--|-----------------------|
| Script     | Organized, complete, accurate and executes.   | Missing minor parts, but executes and is otherwise organized and accurate.         | Missing significant portions of the activity, unorganized, inaccurate, but executes. | Code does not execute |
| Annotation | Annotations are complete and describe what the code is accomplishing.   | Some annotations are incomplete or do not describe what the code is accomplishing. | Annotations were not included.   | Code does not execute |
| Discussion | Insightful discussion or commentary relating to the question at hand demonstrating student understanding of the task. | Discussion or commentary was partially incomplete.                                 | Minimal to no discussion or commentary.  | Code does not execute |

Figure 14. Sample grading rubric and deliverable

In one early activity, students are asked to create a plot which shows the transit stop level data in the x-y coordinate plane with an additional data variable encoded with color. The code the students develop is shared the following class period as a learning and peer comparison activity. Even with this simple instruction, there have many variations on the plots that students create. Figure 15 shows one of the better plots generated by a student. Most of the students plot the entire day at once, limiting the patterns that can be detected from the data but this student quickly recognized that data must be organized by trio direction and time of day.

The course works towards a set of independent research questions that the students chose based on their interest level. These research questions will use most of the techniques that the students have learned in course sequence. These research statements are predefined but generally open ended to allow students to explore in a number of different ways. In the four years the course has been taught, no two students have approached a problem in the same way. The potential research questions address each of the class data sets:

- Topic 1: Assessing The Accessibility of Trimet Bus Stops

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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- Topic 2: Assessing Trimet Bus Headway Reliability
- Topic 3: Exploring Bicycle Performance
- Topic 4: Freeway Data and Incidents
- Topic 5: Freeway Data and Weather
- Topic 6: WIM Data – Side By Side Loadings

There are a number of supplementary files supporting these activities that are included on the course companion website (some are limited to instructors only). These type of files are listed below.

1. R Sample Scripts (21 script files)
2. Lecture PPT Slides (12 PPT files to introduce certain activities)
3. Metadata Description Files (clear descriptions of all data tables and field definitions)
4. Raw Data Tables (in CSV and pgdump format)
5. Multiple Choice Reading Quizzes (10 quiz files to encourage readings)

A separate document is included that has instructor guidance and solution R Scripts.

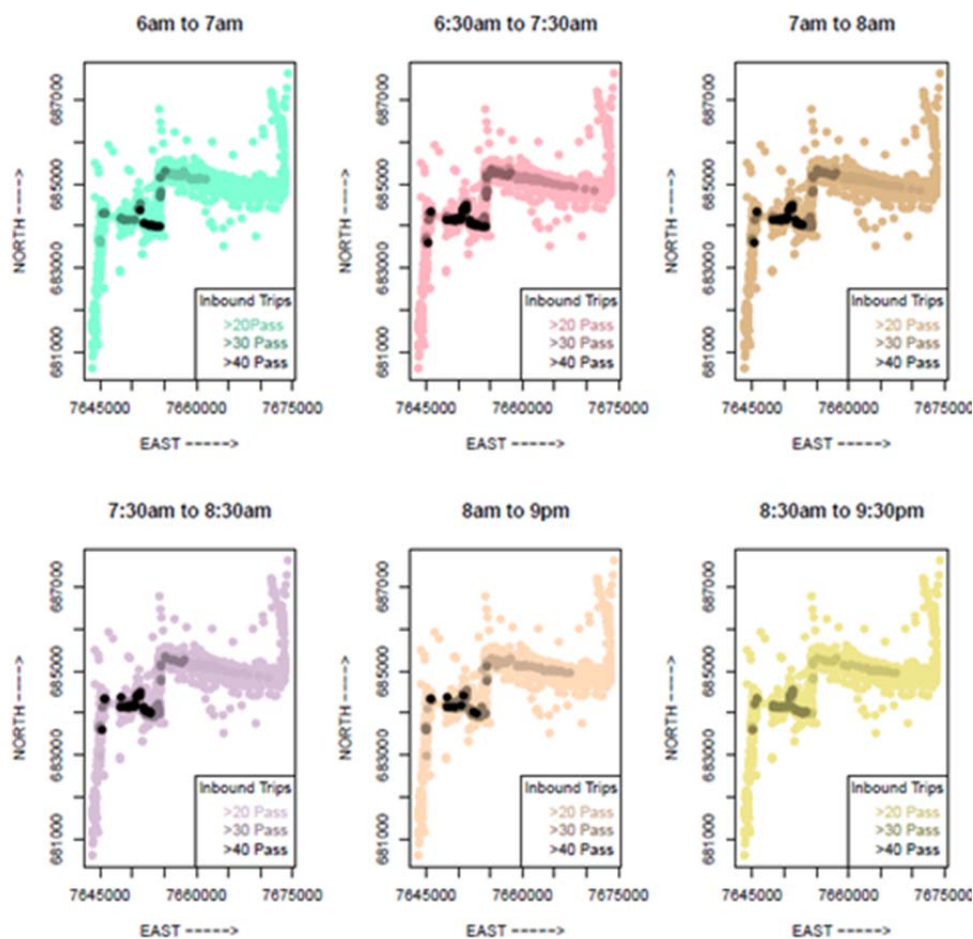


Figure 15. Sample plot showing the passenger loading in 30 minute steps for inbound route 19 trips (Credit: Joel Barnett)

### 3.3 University of Washington Course

The University of Washington developed a course entitled “Introduction to Freight Transportation.” The course is intended to be an exploration of how freight fits into the larger transportation system. It is also intended to be an introduction to applications of freight modeling serving to enrich the overall knowledge base of a transportation engineer, as well as providing a gateway for further study in research in the field of freight transportation modeling. The course is based on the completion of ten activities.

The class has three objectives:

- Exposing students to base knowledge
- Expanding their understanding
- Applying their understanding.

Seven units were developed to support these objectives:

- Unit 1: Defining the freight system
- Unit 2: Contemporary issues
- Unit 3: Stakeholders and incentives
- Unit 4: Performance measures
- Unit 5: Policy and impacts on performance
- Unit 6: Aggregate modeling
- Unit 7: Fleet modeling

Units 1 through 3 build students' base knowledge of the field. Units 4 through 5 expand their understanding of freight transportation, and the last two units require students to build upon their understanding by applying the concepts that they have learned (as seen in Figure 16). The course content consists of lectures, class activities, and readings to expand student understanding within freight transportation.

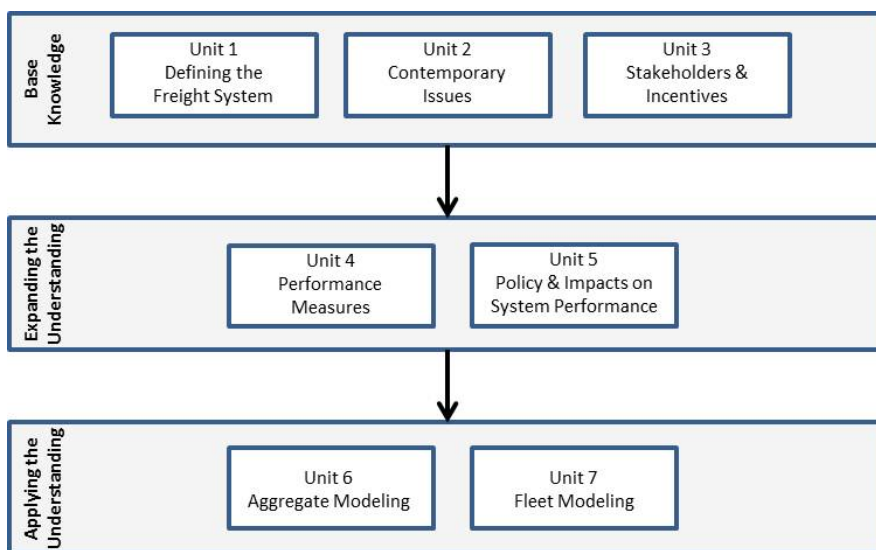
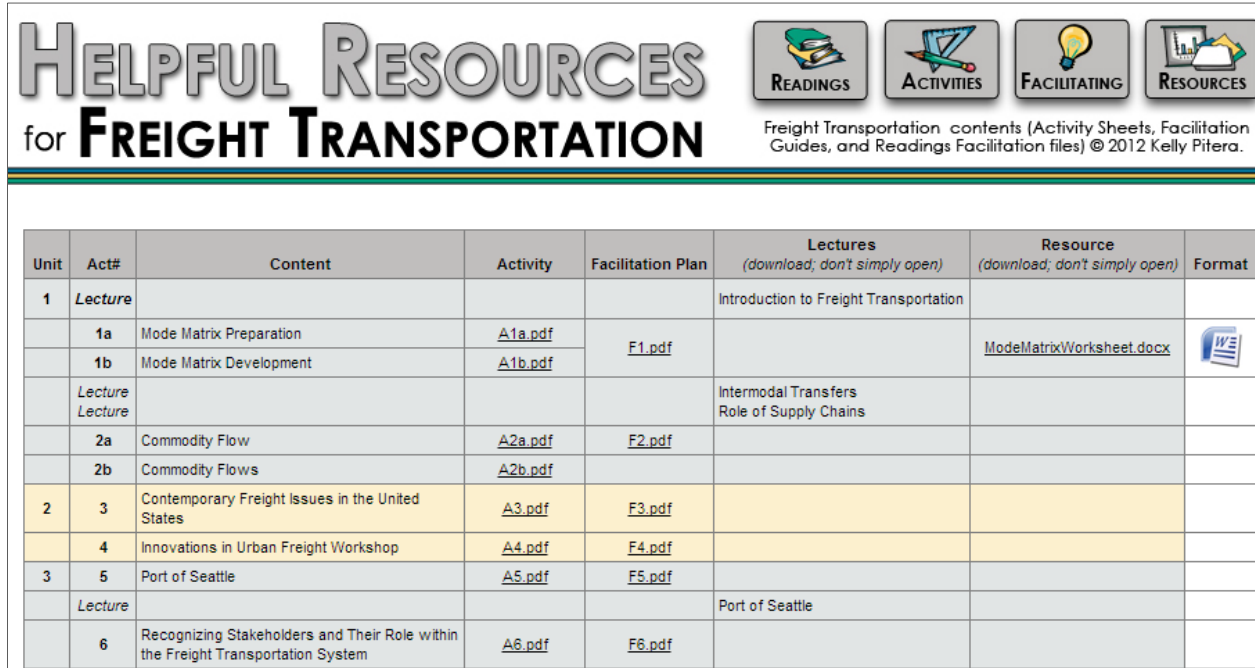


Figure 16. Organization of course

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

A web site has been established from which all course materials can be accessed (see Table 2 for URL information and Figure 17 for a screenshot of the web site). The website is accessible to instructors and includes student activity resources, facilitation plans to assist instructors in preparing for and conducting the activities, reading guides and lecture files.




| Unit | Act#    | Content  | Activity                | Facilitation Plan | Lectures<br><i>(download; don't simply open)</i> | Resource<br><i>(download; don't simply open)</i> | Format  |
|------|---------|--|-------------------------|-------------------|--|--|---|
| 1    | Lecture |  |                         |                   | Introduction to Freight Transportation           |  |   |
|      | 1a      | Mode Matrix Preparation  | <a href="#">A1a.pdf</a> | F1.pdf            |  | <a href="#">ModeMatrixWorksheet.docx</a>         |  |
|      | 1b      | Mode Matrix Development  | <a href="#">A1b.pdf</a> |                   |  |  |   |
|      | Lecture |  |                         |                   | Intermodal Transfers<br>Role of Supply Chains    |  |   |
|      | 2a      | Commodity Flow   | <a href="#">A2a.pdf</a> | F2.pdf            |  |  |   |
|      | 2b      | Commodity Flows  | <a href="#">A2b.pdf</a> |                   |  |  |   |
| 2    | 3       | Contemporary Freight Issues in the United States                                 | <a href="#">A3.pdf</a>  | F3.pdf            |  |  |   |
|      | 4       | Innovations in Urban Freight Workshop  | <a href="#">A4.pdf</a>  | F4.pdf            |  |  |   |
| 3    | 5       | Port of Seattle  | <a href="#">A5.pdf</a>  | F5.pdf            |  |  |   |
|      | Lecture |  |                         |                   | Port of Seattle                                  |  |   |
|      | 6       | Recognizing Stakeholders and Their Role within the Freight Transportation System | <a href="#">A6.pdf</a>  | F6.pdf            |  |  |   |

Figure 17. Course materials web site, Introduction to Freight Transportation course



Table 6 lists the materials prepared for the course, including the name of each activity and its type.

**Table 6. Material List for the Introduction to Freight Transportation course**

| Unit                                       | Activity   | Type                               |
|--|--|------------------------------------|
| 1: Defining the Freight Systems            | Introduction to Freight Transportation                 | Lecture                            |
|  | Mode Matrix  | In-class/out of class activity     |
|  | Intermodal Transfers                                   | Lecture                            |
|  | Role of Supply Chains                                  | Lecture                            |
|  | Commodity Flow   | In-class/out of class activity     |
|  | The Freight Story 2008                                 | Reading                            |
|  | What is Intermodal Transportation                      | Reading                            |
|  | How Intermodality Developed in the United States       | Reading                            |
|  | The Container Revolution                               | Reading                            |
|  | The Secret life of the Container                       | Reading                            |
| 2: Contemporary Issues                     | Contemporary Issues                                    | In-class activity                  |
|  | Innovations in Urban Freight                           | Out of class activity              |
| 3: Stakeholders & Incentives               | Port of Seattle  | Out of class activity              |
|  | Identifying Stakeholders                               | In class and out of class activity |
|  | Beyond the Obvious                                     | In-class and out of class activity |
| 4: Performance Measures                    | Freight Performance Measures                           | Lecture                            |
|  | Minnesota Statewide Freight Plan: Performance Measures | Reading                            |
|  | Freight Technology Story                               | Reading                            |
| 5: Policy & Impacts on Systems Performance | Freight and the Economy                                | Lecture                            |
|  | Freight Transportation Policy                          | Lecture                            |
|  | Modal Conflict Project                                 | In-class and out of class activity |
|  | Government Regulation and Deregulation                 | Reading                            |
|  | Economic Effects of Transportation: The Freight Story  | Reading                            |
|  | Economic Impacts of US Freight Railroads               | Reading                            |
|  | E-Business Challenges for Intermodal Freight           | Reading                            |
| 6: Aggregate Modeling                      | Aggregate Freight Modeling                             | Lecture                            |
|  | Regional Truck Modeling                                | Lecture                            |
|  | Freight Analysis Framework                             | In-class activity                  |
|  | A Fleet of One   | Reading                            |
| 7: Fleet Modeling                          | Fleet Modeling   | Lecture                            |
|  | Fleet Modeling   | In-class activity                  |
|  | Freight Transportation for Urban Area                  | Reading                            |

Each activity is based on a consistent format which includes identifying the activity purpose, learning objectives, resources, tasks, and deliverables. Figure 18 shows an example of a student activity sheet focused on current freight issues.

### CONTEMPORARY FREIGHT ISSUES IN THE UNITED STATES

ACTIVITY 3

**PURPOSE**

This activity will help you gain a better understanding of the current issues associated with freight transportation, including what the issues concern and how they impact the community. Within the context of this assignment, the term freight transportation has a very broad meaning, including the vehicles, infrastructure, and stakeholders associated with and impacted by goods movement, and the economic, social and environmental issues and impacts of goods movement.

**LEARNING OBJECTIVES**

- To be able to describe common current issues regarding freight transportation.
- To understand how freight and freight issues impact our society and communities.

**REQUIRED RESOURCE**

- Current newspaper

**TASKS**

In this lesson you will gather with other students in groups of two or three. Using your assigned newspaper, you will identify all articles which relate to freight issues. Be sure to look carefully within the article, not solely at the headline. You may find, for example, that an article in the arts or travel section, may relate to freight transportation in some way. For each article, complete the following tasks:

1. Indicate if the article relates to freight and how it impacts society, or relates to how society impacts freight.
2. Categorize the impact (e.g., economic, environmental...). Develop your own categories.
3. Provide a one to two sentence summary of the freight issue within the article.

Once each group has finished, groups will take turns sharing their issues with the class. A compiled list of issues (and categories) will be developed. The activity will conclude with an instructor-led discussion of the contemporary issues.

**DELIVERABLES**

Each group will develop a list of articles with relationships to society, categories and summary. Students are expected to participate in group work and class discussion.

**Figure 18. Excerpt from Activity #3**

In addition, the web site includes 16 readings, two modeling worksheets, and nine PowerPoint files to facilitate lectures. A facilitation guide includes information on how to conduct each activity. Figure 19 shows an excerpt of the discussion notes provided in the facilitation guide for Activity #3.

***DISCUSSION NOTES/IDEAS***

For the discussion:

- Do freight issues only fall under one category?
- What is the distinction between “freight impacting society” and “society impacting freight”?
- Are there issues that are consistently mentioned by all papers? Are some issues regional? What are they?
- From the list of freight issues that we have developed, which issue do you think is the most interesting (and why)? Which do you think is the most important?
- Are there any freight issues that you can think of which were not identified in the newspapers we’ve looked at?
- (TO BE ASKED OF A SPECIFIC ISSUE) Can you identify the stakeholders of the issue?
- (TO BE ASKED OF A SPECIFIC ISSUE) To what level of government does this issue relate?
- (TO BE ASKED OF A SPECIFIC ISSUE) By what means do you think this issue could be fixed: policy, construction/engineering, education, something else?

Figure 19. Excerpt from the facilitation guide

**3.4 University of Alaska Course**

The University of Alaska developed a course entitled “Rural Highway Design and Safety.” The course is intended to teach students highway geometric design and safety performance analysis with a rural highway realignment project divided into individual learning activities.

A web site has been established from which all course materials can be accessed (see Table 2 for URL information and Figure 20 for a screenshot of the web site).

# HELPFUL RESOURCES



## for RURAL HIGHWAY DESIGN AND SAFETY: COURSE ACTIVITY BOOK

| Frontis | Title, Table of Contents  | Filename | Format |
|---------|---|----------|--------|
| CH 1    | <a href="#">Introduction</a>  |          |        |
| CH 2    | <a href="#">Concepts in Highway Design and Safety</a>   |          |        |
| Act 1   | <a href="#">Basic Concepts in Highway Design and Safety</a>   |          |        |
| Act 2   | <a href="#">Highway Functional Classification Concepts (Reading)</a>  |          |        |
| Act 3   | <a href="#">Concepts of Highway Development Process (Reading)</a>   |          |        |
| CH 3    | <a href="#">Highway Design Fundamentals: Design Controls and Criteria, &amp; Elements of Design</a>                           |          |        |
| Act 4   | <a href="#">Reading and Discussion on Concepts of Highway Design Controls and Criteria (Reading)</a>                          |          |        |
| Act 5   | <a href="#">Determination of Design Controls and Criteria (Design)</a>  |          |        |
| Act 6   | <a href="#">Highway Design Elements (Reading)</a>   |          |        |
| CH 4    | <a href="#">Introduction to Highway Safety Manual</a>   |          |        |
| Act 7   | <a href="#">Reading and Discussion on the Fundamentals of Highway Safety Manual (Reading)</a>                                 |          |        |
| Act 8   | <a href="#">Predicting Highway Safety for Two-lane Rural Highway Segments (Analysis)</a>                                      |          |        |
| CH 5    | <a href="#">Highway Alignment</a>   |          |        |
| Act 9   | <a href="#">Checking for Compliance to Design Standards: Horizontal Curves, Grades, &amp; Superelevation Rates (Analysis)</a> |          |        |
| Act 10  | <a href="#">Alignment Design (Design)</a>   |          |        |
| CH 6    | <a href="#">Highway Cross Section and Roadside Design</a>   |          |        |
| Act 11  | <a href="#">Highway Cross Section and Roadside Design (Reading)</a>   |          |        |
| Act 12  | <a href="#">Typical Sections Design (Design)</a>  |          |        |
| Act 13  | <a href="#">Roadside Barrier (Design)</a>   |          |        |
| Act 14  | <a href="#">Earthwork Estimation (Analysis)</a>   |          |        |
| CH 7    | <a href="#">Safety Performance Estimation and Improvement Measures</a>  |          |        |
| Act 15  | <a href="#">Predicting Highway Safety for Two-lane Rural Highway Segments (Analysis)</a>                                      |          |        |
| Act 16  | <a href="#">Identify Safety Improvement Measures &amp; Produce a Design Alternative Incorporating Them (Design)</a>           |          |        |
| CH 8    | <a href="#">Project Cost Estimation and Preferred Alternative Selection</a>   |          |        |
| Act 17  | <a href="#">Estimate Cost of the Design Alternatives and Selection of a Preferred Alternative (Analysis)</a>                  |          |        |
| Act 18  | <a href="#">Project Final Presentation and Reporting (Reporting)</a>  |          |        |

| Filename  | Format |
|---|--------|
| <i>Do not simply click to open these files. You will need to download them (right click and Save As).</i> |        |
| <a href="#">A5 design_controls_criteria.xlsx</a>  |        |
| <a href="#">A9 design_compliance.xlsx</a>   |        |
| <a href="#">AKDOT Barrier_Length_Calculation.xlsx</a>   |        |
| <a href="#">Elliott_xsections.pdf</a>   |        |
| <a href="#">glenn_typical_section.pdf</a>   |        |
| <a href="#">Plan_n_Profile.pdf</a>  |        |
| <a href="#">STIP_sheet.pdf</a>  |        |
| <a href="#">Taylor_hwy_typical_section.pdf</a>  |        |
| <a href="#">Unit_cost.docx</a>  |        |

Click to download the book in a single pdf file.

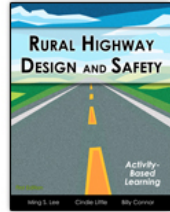


Figure 20. Course materials web site for Rural Highway Design and Safety course

The activities for this course are listed in Table 7.

**Table 7. Activities for Rural Highway Design and Safety course**

| Chapter | Activity # | Activity name   | Activity type |
|---------|------------|---|---------------|
| 1       |            | Introduction (Chapters overview)  |               |
| 2       |            | Concepts in Highway Design and Safety   |               |
|         | 1          | In-class Reading on Basic Concepts in Highway Design and Safety                                     | Reading       |
|         | 2          | Pre-class reading on highway functional classification concepts                                     | Reading       |
|         | 3          | Pre-class reading on concepts of highway development process  | Reading       |
| 3       |            | Highway Design Fundamentals: Design Controls and Criteria, and Elements of Design                   |               |
|         | 4          | Pre-class reading and discussion on concepts of highway design controls and criteria                | Reading       |
|         | 5          | Determination of design controls and criteria   | Design        |
|         | 6          | Pre-class reading on highway design elements  | Reading       |
| 4       |            | Introduction to Highway Safety Manual   |               |
|         | 7          | Pre-class reading and discussion on the fundamentals of Highway Safety Manual                       | Reading       |
|         | 8          | Predicting highway safety for two-lane rural highway segments                                       | Analysis      |
| 5       |            | Chapter 4 Highway Alignment Design  |               |
|         | 9          | Checking for Compliance to Design Standards: Horizontal Curves, Grades, and Superelevation Rates    | Analysis      |
|         | 10         | Alignment Design  | Design        |
| 6       |            | Chapter 5 Highway cross section and roadside design   |               |
|         | 11         | Reading on highway cross section and roadside design  | Reading       |
|         | 12         | Typical sections design   | Design        |
|         | 13         | Roadside Barrier  | Design        |
|         | 14         | Earthwork Estimation  | Analysis      |
| 7       |            | Chapter 6 Safety Performance Estimation and Improvement Measures                                    |               |
|         | 15         | Predicting highway safety for two-lane rural highway segments                                       | Analysis      |
|         | 16         | Identify safety improvement measures and produce a design alternative that incorporate the measures | Design        |
| 8       |            | Chapter 7 Project Cost Estimation and Preferred Alternative Selection                               |               |
|         | 17         | Estimate cost of the design alternatives and selection of a preferred alternative                   | Analysis      |
|         | 18         | Project final presentation and report   | Reporting     |

Each chapter of the activity book groups activities based on a particular subject. The activities of this course can be categorized into two types: reading/discussions and group design activities. Chapters 2 to 4 are mostly reading activities. Materials for the reading activities are selected from references of highway design standards, including *A Policy on Geometric Design of Highways and Streets 2011* (the Green Book), *Roadside Design Guide 4<sup>th</sup> edition* (2011), and *Highway Safety Manual 1<sup>st</sup> Edition* (2010). All three references are published by the American Association of State Highway and Transportation Officials (AASHTO). Chapters and sections selected for the reading activities are basic subjects covering materials required for the group design project.


Chapters 4 to 8 contain activities that make up a rural highway realignment project. The project selected for the group design activities is a highway realignment project in Alaska. The tasks of this realignment project were adapted into a simplified version that contains focused subjects covered in this course. By completing these activities, students learn the critical steps in a highway design process and produce a report documenting their design work.

Each activity is based on a consistent format:

- The *Purpose* tells students the primary subject they are going to learn.
- The *Learning Outcomes* describe specific accomplishments of the activity.
- The *Resources* identify a set of materials and supports for students to complete the activity.

- The *Critical Thinking Questions* give students opportunities to discover the most important knowledge and experience of the activity.
- The *Tasks* list the specific steps that students will need to follow.
- The *Deliverables* describe what students are expected to produce.
- The *Information* provides additional ideas or notes that will help the students complete the activity.

Figure 21 shows excerpts from an example activity in which students learn the concepts of highway design controls and criteria by reading the AASHTO Green Book.

**ACTIVITY 4** **READING AND DISCUSSION ON CONCEPTS OF HIGHWAY DESIGN CONTROLS AND CRITERIA** 

**PURPOSE** **LEARNING OBJECTIVE**

To provide you an opportunity to become familiar with highway design controls and criteria as stated in AASHTO's *Green Book*.

- Be able to identify major groups of design controls and criteria
- Be able to describe the relationships between highway design controls and geometric elements

**REQUIRED RESOURCES**

- Chapter 2 of AASHTO's *Green Book*
- Answer sheet for the Critical Thinking Questions

**CRITICAL THINKING QUESTIONS**

1. What are highway design controls and criteria?
2. What is a design vehicle?
3. What aspect of driver performance is most critical in determining stopping sight distance?
4. What is design speed? What design features are directly related to the design speed selected?
5. How does traffic volume of a highway control its design?
6. How does the expected capacity of a highway controls its design?

**TASKS**

Read the assigned reading material. Write down your answers to the Critical Thinking Questions. Prepare to discuss your thoughts in class.

**DELIVERABLE**

The completed answer sheet.

**INFORMATION**

AASHTO defines Design Controls and Criteria as "the characteristics of vehicles (vehicles and drivers), pedestrians, and traffic that act as criteria for the optimization or improvement in design of the various highway and street functional classes." Determining design controls and criteria is a critical step in highway design as the established controls and criteria determine the values that can be applied for various design elements. For example, a project with high design speed cannot be designed with sharp curves.

Chapter 2 of the *Green Book* discusses various design controls and criteria. The discussions in this chapter act as resources for highway designers in understanding the concepts, evaluating specific considerations, and choosing appropriate values for the design controls and criteria that are relevant to a project.

Figure 21. Excerpt from Activity #4

In addition, the web site includes nine supplemental files for the students and instructors.

## CHAPTER 4. ASSESSMENT AND EVALUATION

This chapter presents the results of a series of assessments that were conducted throughout this project as the new curricula were developed and deployed. The project objectives, as stated in the proposal, are to “enhance the quality of the learning environment for transportation students” “through an active problem-based learning environment conducted at a distance” to “university students and practicing professionals.” With these objectives in mind, the assessment is focused on the learning environment, student learning, curriculum materials, and faculty reflections on the process.

Sections 4.1 and 4.2 focus on the learning environment that was created. A classroom learning environment survey was conducted to determine how students perceived the effectiveness of their learning environment as it related to interaction and engagement, authentic open-ended problems, and communication skills. Students were also surveyed on the effectiveness of activity-based learning both in the traditional (live) classroom as well as in a distance learning environment.

Sections 4.3 and 4.4 focus on the impacts of the methods and materials on student learning. Evaluations of conceptual understanding were conducted using pre and post assessments to determine how student understanding of key concepts changed as a result of the courses. A comparative case study was also used to determine the effectiveness of the materials. Finally, a two-day peer review of the materials was conducted to obtain feedback on the effectiveness of the materials.

Section 4.5 presents faculty reflections on what they learned in the development and use of the new activity-based learning materials. Section 4.6 provides a summary of what the project team learned from the assessment and evaluation.

### 4.1 Student Perception of the Learning Environments and Learning Outcomes

Student perceptions of their learning environments and the course learning outcomes were measured with two instruments. The first was a survey instrument with a common set of questions administered to students in the last week of each of the four participating courses. This survey assessed how the classroom environment aligned with the project objectives stated above. The second was a survey conducted among students at the University of Idaho from the Traffic Signal Systems Operations and Design course. The results from both of these assessments are presented in this section.

#### Common Assessment Questions

In order to gain greater understanding of student perceptions regarding their learning environment, students were asked to answer a set of questions based on five learning objectives:

1. To enhance the learning environment for transportation students
2. To engage students in a problem based learning environments to produce students who perform better at solving novel problems

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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3. To provide students opportunities to network with professionals and gain a real understanding of the field
4. To encourage the development of essential communication and collaboration skills that replicates the work environment
5. To provide a motivating and interesting learning environment and curriculum

Multiple questions were asked for each of the five learning objectives. Each question utilized a either an agreement or a frequency scale with a corresponding 1 to 5 response range. The agreement scale, includes Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) and Strongly Agree (5) and the frequency scale includes Never (1), Rarely (2), Sometimes (3), Often (4) and Very Often (5). The survey was implemented at the end of the term in the 2011-2012 academic year for each participating course and for one control course. The control course was a lecture-style course in transportation engineering at a university not associated with this project. Although the comparison course is only a single course it does provide some insight into how much different the four participating courses were from a self-reported “typical lecture course”.

The results are presented in Table 8 and Table 9 with the average and standard deviation shown for each question at each university. For example, at the University of Idaho, the “Ask the instructor questions” had an average response of 3.5 and a standard deviation of 1.0. This means that most University of Idaho students responded with either Sometimes or Often in response to this question.

The overall survey responses indicate that students had substantial opportunities to ask the instructor and other students questions, to work on open-ended authentic design problems, to interact with and learn from practicing professionals, to practice and improve their written and verbal communication skills, and that the course content was interesting, useful, and important. Almost all responses at all universities are between 3 and 5, with most responses near 4. This means that most students responded with either ‘Often’ on the frequency scale questions or ‘Agree’ on the agreement scale questions. For example, the average response for participating universities on the question “Course material is useful to learn” was 4.4 with a standard deviation of 0.5. This means that about 70% of the students either ‘Agree’ or ‘Strongly Agree’ with this statement. Similarly, student responses to the “In this course I work on questions with multiple solutions” had an average value of 3.9 with a standard deviation of 0.7. Thus, most students responded with either ‘Sometimes’ or ‘Often’ to this question. Collectively, survey responses indicate that students believed that the classroom environment was positive in terms of the project objectives stated at the beginning of this section.

Responses shown in bold note either that the average of the participating university responses is higher than for the control university or that responses from one university are higher than all other universities. The average response for four of the five classroom environment questions for the four participating universities was about 0.8 points higher than the comparison university. This is not surprising given the explicit goal of this project to provide an active learning environment where students have extensive opportunities to interact with other



students and the instructor. This provides more evidence that the project was effective in implementing the classroom environment it was intended to.

**Table 8. Common Assessment Questions and Responses**

| Question   | University of Idaho | Portland State University | University of Washington | University of Alaska | Average of Participating Universities | Comparison University |
|--|---------------------|---------------------------|--------------------------|----------------------|---------------------------------------|-----------------------|
| <b>Classroom Environment (frequency scale)</b>   |                     |                           |                          |                      |                                       |                       |
| Ask the instructor questions   | 3.5 (1)             | 3.1 (0.7)                 | 3.8 (0.8)                | 3.6 (0.3)            | <b>3.6 (0.6)</b>                      | <b>2.4 (0.9)</b>      |
| Ask fellow students questions  | 3.8 (0.7)           | 3.5 (1.4)                 | 3.7 (1.1)                | 2.9 (0.8)            | 3.4 (0.9)                             | 3.4 (1.7)             |
| Work with other students on a problem or exercise  | <b>4.4 (0.7)</b>    | 3.1 (1.2)                 | 3.7 (1.1)                | 4.1 (0.8)            | <b>3.9 (0.8)</b>                      | <b>3.1 (1.6)</b>      |
| Explain my ideas to other students   | <b>4.1 (0.7)</b>    | 3.3 (1.2)                 | 3.8 (1.3)                | 3.4 (0.7)            | <b>3.6 (0.9)</b>                      | <b>3.1 (1.7)</b>      |
| Listen to other students explain their ideas to me   | <b>4 (0.7)</b>      | 3.3 (1.2)                 | 4 (1.3)                  | 3.4 (0.7)            | <b>3.6 (0.8)</b>                      | <b>3 (1.6)</b>        |
| <b>Open-ended Authentic Problems (frequency scale)</b>   |                     |                           |                          |                      |                                       |                       |
| In this course I work on problems that have multiple solutions.  | 4.1 (0.7)           | 4.2 (0.8)                 | 4.1 (0.6)                | 3.3 (0.5)            | 3.9 (0.7)                             | 3.7 (0.7)             |
| In this course I work on problems that are open-ended.   | 4 (0.8)             | 3.9 (0.9)                 | 4.1 (0.6)                | 3 (0.8)              | 3.8 (0.8)                             | 3 (0.8)               |
| Problems in this course are like what I expect to see in professional practice.  | 4 (0.8)             | 3.8 (0.8)                 | 3.6 (0.5)                | 4 (0.8)              | 3.8 (0.7)                             | 3.3 (1.2)             |
| <b>Interactions with Professionals in Course (frequency-1<sup>st</sup> two questions, agreement scale-3<sup>rd</sup> question)</b> |                     |                           |                          |                      |                                       |                       |
| I interact with industry professionals during class.   | 4.2 (0.7)           | 3.1 (1.3)                 | 3.6 (1.2)                | 3 (0.8)              | 3.5 (1.0)                             | 3.7 (1.2)             |
| I interact with industry professionals outside of class.   | 4 (1.1)             | 2.8 (1.4)                 | 3.4 (1)                  | 2 (0.8)              | 3 (1.1)                               | 4 (0.8)               |
| Interacting with these individuals is helpful to my learning   | 4.6 (0.5)           | 3.9 (0.9)                 | 4.4 (0.8)                | 3 (0)                | 4 (0.6)                               | 4.3 (0.5)             |

Student responses from the University of Idaho were substantially higher in two categories, ‘Classroom Environment’ and ‘Teamwork and Communication Skills’. Although it is difficult to tell why this is true, it may be attributed to the teacher of this course having substantially more experience teaching using an active learning style. Also, student responses for the ‘Motivation and Interest’ questions were substantially higher for the Portland State University students than all other students. At first glance this is surprising because this is a probability and statistics course. However, other assessment data suggest that the extensive use of real-life data sets and examples in this course was effective in students seeing how this content was very valuable and applicable in other courses and future work.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

**Table 9. Common Assessment Questions and Responses (continued)**

| Question  | University of Idaho | Portland State University | University of Washington | University of Alaska | Average of Participating Universities | Comparison University |
|---|---------------------|---------------------------|--------------------------|----------------------|---------------------------------------|-----------------------|
| <b>Teamwork and Communication Skills (frequency scale-1<sup>st</sup> 3 questions, agreement scale-last 3 questions)</b> |                     |                           |                          |                      |                                       |                       |
| I practice my verbal communication skills in this course.   | <b>3.8 (0.7)</b>    | 3.2 (0.8)                 | 3.7 (0.7)                | 3 (0.8)              | 3.4 (0.7)                             | 4.2 (0.7)             |
| I practice my written communication skills in this course.  | <b>4.1 (0.7)</b>    | 3.6 (0.7)                 | 4.1 (0.6)                | 3 (0.8)              | 3.7 (0.7)                             | 4 (1)                 |
| I collaborate with others in this course.   | <b>4.4 (0.7)</b>    | 3.1 (0.6)                 | 3.9 (0.3)                | 3.7 (0.5)            | 3.8 (0.5)                             | 4.2 (0.7)             |
| My verbal communication skills are enhanced because of this course.   | <b>4 (0.7)</b>      | 3.6 (0.7)                 | 3.6 (0.5)                | 2.7 (0.5)            | 3.4 (0.6)                             | 3.5 (1.3)             |
| My written communication skills are enhanced because of this course.  | <b>4 (0.7)</b>      | 3.6 (0.8)                 | 3.9 (0.6)                | 2.7 (0.5)            | 3.5 (0.7)                             | 3.5 (1.4)             |
| My ability to work effectively with others is enhanced because of this course.  | <b>4.3 (0.6)</b>    | 3.3 (0.7)                 | 3.7 (0.5)                | 3.3 (0.5)            | 3.7 (0.6)                             | 3.7 (0.9)             |
| <b>Motivation and Interest (agreement scale)</b>  |                     |                           |                          |                      |                                       |                       |
| I am interested in the content area of this course.   | 4.2 (0.8)           | <b>4.6 (0.5)</b>          | 4.1 (0.6)                | 4.5 (0.5)            | 4.3 (0.6)                             | 4.2 (0.7)             |
| Course material is useful to learn.   | 4.2 (0.7)           | <b>4.7 (0.5)</b>          | 4 (0.5)                  | 4.5 (0.5)            | 4.4 (0.5)                             | 4.3 (0.5)             |
| Studying appropriately, I can learn the material.   | 4.5 (0.7)           | <b>4.7 (0.5)</b>          | 4 (0.5)                  | 4 (1)                | 4.3 (0.7)                             | 4.3 (0.7)             |
| It is important for me to learn what is being taught in this course.  | 4.2 (0.7)           | <b>4.6 (0.7)</b>          | 3.9 (0.3)                | 4 (1)                | 4.2 (0.7)                             | 4.2 (0.7)             |
| I think I will be able to use what I learn in this course in other courses.   | 3.9 (0.9)           | <b>4.9 (0.3)</b>          | 4.1 (0.6)                | 3 (0)                | 4 (0.5)                               | 4.3 (0.5)             |
| Understanding this subject is important to me.  | 4.1 (0.8)           | <b>4.4 (0.7)</b>          | 4.1 (0.6)                | 4.5 (0.5)            | 4.3 (0.7)                             | 4.3 (0.5)             |

### Survey of University of Idaho Students

Assessments were completed for the Traffic Signal Systems Operations and Design course each of the six times that the course was offered as part of this project. The following information was synthesized from the most recent assessment, completed after the twenty students in the course had finished their first design project (and the first ten weeks of the course) and completed the 63 activities of the “Traffic Signal Systems Operations and Design” book during the fall semester 2012. Since the final version of the activity book was used by the students during this term, this assessment is the most useful one to review in this report. The results from this assessment focus on general aspects of the class and the classroom environment.

### *General Aspects of the Class*

Students were asked what they liked and didn't like about the class, providing a general sense of the aspects of the class that helped or hindered their learning. Their responses also provide insight on how the process of active learning needs to be communicated to students, even if its value is not immediately recognized by them.

One thread of student responses was the classification of some of the work as busy or unnecessary work. Eight of the 20 students cited this factor. One student responded:

“The aspect that I disliked the most about the class so far has been the amount of work that has been required. I personally don't believe that everyone needed to do all of the activities to understand the material. I believe that some activities would have been better left up to us to do for our own good.”

The assumption of the instructor in reviewing these responses is that it is helpful to their learning process if students are asked to follow what they have read with the task of answering a set of critical thinking questions. When students are busy, they often complete the reading with varying degrees of attention, with little time or effort spent on reflecting what they have just read. Having to answer questions, to think critically about what they have read, is often perceived as an annoyance (and student responses support this observation) with little value seen in taking the time to answer the questions.

Another perception cited by one student was the expectation that “better” or “more real” learning occurs when there is more information provided by the instructor that is less conceptual and more technical detail. This student speaks to a view held by some students that they would like more balance in the learning process:

“As we move through topics, I am hungry for just a bit more instruction and information, rather than just activities and projects. Most classes are too far the other way, but I would really benefit from just a little more lecturing, [fewer] too many small-medium assignments piled on top of each other.”

But an equally large number of students (eight of 20) said that they liked the different ways of learning provided in the class. One student acknowledged a begrudging acceptance and valuing of the active learning environment:

“Forced to be attentive (we may not like that, but it's good for us). Thorough examination of topics. We really get them, rather than glossing over a bunch of topics.”

Three other similar comments support the view that the variety of ways of learning, and the more activity during class, helps them:

“The ability to learn in numerous formats. Watching videos, analyzing data, changing parameters, and seeing the results through VISSIM MOE's.”

“I like that we go over topics in a variety of ways, introducing them first in a reading, then activities, then actually applying in the project. It was a great way to build a solid foundation of understanding.”

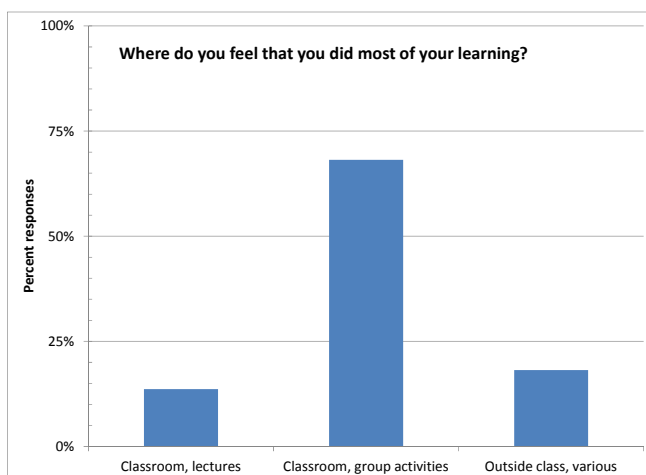
“I like the connections between lectures and labs work. It makes learning much easier when you can relate simulation model with real life traffic character.”

Four of the 20 students related to the use of the VISSIM simulation model. One student noted that “...seeing a modeling system was fun and felt practical to what a professional may do.”

### *Issues Relating To Classroom Environment*

Students were asked to identify those parts of the classroom environment that contributed to their learning. A number of students pointed positively to the degree of group work in the class. For example, students liked being able to check their work with their group members and relied on other members to help them if they didn't understand a given topic. A related topic, classroom discussion, was identified by three students as being helpful. Both group work and discussions keep students active during the classroom and seem to encourage student learning and engagement.

When students were asked to identify where they did most of their learning, two-thirds of them responded “classroom, group work” (See Figure 22). This is consistent with how the instructor tried to structure their time and they validated his intent. Only a small number of students cited classroom lectures or work conducted outside of class (such as field work) as significant in their learning.



**Figure 22. Learning styles**

Another quote supported these findings:

“The interactive environment forced students to keep up with the class and actively engage in critical thinking.”

One final quote describes the need for the instructor to provide a better perspective on how the various activities fit together to form the design process:

“I would recognize the fact that all of those select activities were actually part of a single design problem; I honestly didn’t realize that we were working on one of the “design projects” mentioned in the syllabus until we were almost done. “

### **4.2 Effectiveness of Distance Learning**

The University of Idaho’s Traffic Signal Systems Operations and Design course was offered in a distance-learning environment in spring 2011 to three university campuses: the University of Washington, Portland State University, and the University of Idaho. Since one of the schools was on the semester system and the other two were on the quarter system, a common ten-week period was identified during which the course was delivered (January-March 2011). The class met twice weekly, 90 minutes in a live mode and 90 minutes in an off-line mode. The live mode utilized compressed-video equipped classroom on the three campuses in which students and instructors could see and hear all participants. While the major portion of the teaching was done by a University of Idaho instructor, the other two sites each had an on-site instructor. The off-line session was taught and managed by the site instructor, though real time communications was maintained from the Portland State University and University of Washington students to the primary instructor at the University of Idaho.

Based on a survey instrument administered at the end of the ten-week common period, most of the students enjoyed and benefited from the course. The following comments from three of the students describe some of the positive reactions:

“It was a fun and unique opportunity to be able to tap into some different areas of expertise by taking a class taught by Idaho faculty; this more than made up for some of the technical difficulties presented by distance learning. I also really enjoyed some of the lab work, particularly the more hands-on projects in VISSIM. During several lectures, I felt that there was some great back-and-forth between Michael and Peter as they discussed different approaches to signal system design and operations. The different interests and backgrounds that the two of you represented made these discussions a lot more interesting and valuable than the typical class setup where you’re only exposed to one viewpoint.”

“I liked having two teachers and two books to support the course. It would have been really difficult to not have a site teacher because communication can be limited during the web sessions. I loved the idea of having the class split time between the computer lab and lecture. It was helpful to introduce topics and then get to apply them.”

“Given that the class was an experiment with distance learning spread across multiple campuses, it was successful despite minor glitches. I really liked the fact that the hours

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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were split between lab and theory which allowed us to apply the theory we learnt during the lecture to visualize the effects of changes in signal timing parameters.”

There were, however, technical issues, especially during the beginning of the course, that negatively impacted the learning environment.

“One negative impact was the communication between sites, it took up more time, and time was limited to begin with.”

“The most apparent difficulty was the distance learning. The technological problems that were encountered negatively affected my learning. I would also suggest changing the class to meet twice per week for 2 hours each instead of 1 ½ hours each.”

“While the distance learning class is novel, cutting edge and sure to be a staple of education in the future, I feel like we are still learning how to do it correctly. We had several tools that worked really well, but I felt like we lost at least 10-15 minutes of class time every week dealing with logistics of distance classes.”

But most of the students saw the value in the course content, and the potential for the active learning environment, particularly as the distance technology became less of a problem as the semester progressed.

“I appreciated the ambition to try the distance course. I know there can be and was some technical issues, but if this is to be a viable option in the future we need to start figuring out how to do it well.”

“It was obvious that both Mike and Peter were passionate about the material and very interested in the students successfully learning the concepts and objectives.”

“I thought the logistics got much better from one week to the next. A lot of the things that I had a problem with early in the class (e.g., difficulty seeing the white board, difficulty asking questions from a distance) were recognized and corrected by the end of the term.”

“Obviously, there are some challenges here for this new course format, but I think the benefits far outweigh the drawbacks and difficulties.”

“Takeaway: This course has incredible potential to be amazing. I think with some work on the activities, distribution of assignments, feedback, and setting and holding students to higher expectations, that this can be a very powerful course.”

In summary, it appears that the distance learning environment allowed for multiple perspectives from different instructors, that students liked having both lecture and lab time

during the distance meeting times, and that the technical issues were an annoyance, but worth the benefits of distance learning.

### 4.3 Student Conceptual Understanding

Student learning was evaluated at the University of Idaho, Portland State University, and the University of Washington. At the University of Idaho, an in-depth comparative qualitative case study was conducted using extensive pre- and post-interviews. This approach provides a high level of detail on students' changing understandings of the important concepts presented in the class. At Portland State University and the University of Washington, a pre-/post- concept test was implemented. A pre-/post-design provides evidence of change that can be mapped to the course experience but with minimal detail of students' descriptive understanding of core concepts.

#### University of Idaho Course

The University of Idaho course on traffic signal timing includes a number of activities in which students observed animations or simulations of traffic flow at a signalized intersection. These videos highlighted differences in efficiency of intersection operations through changes in signal timing parameters. Students observed the simulations, collected data, and were asked questions about the concepts presented within each activity. Concepts explored included timing parameters, actuated controls at signalized intersections, minimum and maximum green time, duration of green indication, cycle length, delay, and passage time. Table 10 shows the relationships between these course activities and their central concepts.

A case study<sup>20</sup> of the effectiveness of these dynamic traffic animations indicated positive change in student understanding of minimum and maximum green time, duration of green indication, as well as relationships between cycle length, delay, and passage time. Compared to other groups not exposed to the simulations, students completing the University of Idaho Traffic Signal Systems Operations and Design course indicated greater understanding of maximum and minimum green time, and duration of green indication. The study utilized pre-post comparative analysis utilizing in-depth clinical interviews of student participants. The research questions guiding the noted study are summarized as follows:

1. Are the animations and associated curriculum effective in improving student learning and overcoming areas of conceptual difficulty?
2. What misconceptions do students have related to concepts in the animations and associated curriculum investigated in this study (e.g. min and max green time, passage time, etc...)?

Four groups of students were interviewed in order to analyze the effectiveness of the animations. The first group, known collectively as Case A, included undergraduate and graduate students participating in a class at UI that utilized animations and activities related to signal timing. Students included in Case A participated in pre- and post- interviews. These

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<sup>20</sup> For discussion of case studies, see: Yin, Robert K. Case study research: design and methods (3rd ed.). Thousand Oaks, Calif.: Sage Publications, 2003.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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semi-structured interviews helped to identify conceptual change amongst student participants. In the study, conceptual change was defined as “any change or refinement of students’ articulation of ideas from pre to post interview”. As a means of external validation and generalization of results, three other groups of students (referred to as Case B, C, and D) were interviewed. Students in Cases B, C, and D participated in courses that taught the same concepts as Case A but without the same level of exposure to animations and the related activities. Table 11 provides a summary of the number and types of participants included in the case study. Sample questions of the pre- and post- interviews are presented in Table 12.



Table 10. Learning outcomes and traffic operations concepts<sup>21</sup>

| Concept ↓                                       | Activity  |  |  |  |  |  |
|---|---|--|--|--|--|--|
|   | Relating the Length of the Detection Zone to the Duration of the Green Indication                                   | Determining the Length of the Minimum Green Time   | Understanding the Variation of Vehicle Headways in a Departing Queue                               | Relating Headway to Unoccupancy Time and Vehicle Extension Time                      | Determining the Effect of the Minor Street VET on Intersection Operations  | Determining the Effect of the Max Green Time on Intersection Operations    |
| <b>Duration of Green Indication (G)</b>         | How does the length of the detection zone affect the time at which the phase in each case terminates.               | Observe how minimum green time can affect phase termination.                               | Determine the longest headway you would want to allow between vehicles before terminating a phase. | —  | Discuss how the passage time setting on the minor street affects the duration of the green interval on the major street. | Determine how maximum green time affects phase termination.                |
| <b>Cycle Length and Delay (CL-D)</b>            | Determine whether or not the phase in each case is operating efficiently or not based on queue clearance and delay. | What are roles of passage time and min green timer in producing efficient intersections.   | —  | Determine the effect of VET on delay by recording when each phase terminates.        | Discuss how the passage time setting on the minor street affects cycle length and delay.                                 | Determine the effect of max green setting on queue clearance and delay.    |
| <b>Passage Time/Vehicle Extension Time (PT)</b> | Set at zero for this simulation.  | Determine the role of passage time in producing efficient operations.                      | Determine maximum allowable headway to help establish the passage time.                            | Determine how the length of the detection zone affects the setting for passage time. | Determine effect of minor street passage time on efficiency of major street and intersection operations.                 | —  |
| <b>Minimum Green Time (min)</b>                 | Set at zero for this simulation.  | When is min green time too long? How long should min green time be to get vehicles moving? | —  | —  | —  | —  |
| <b>Maximum Green Time (max)</b>                 | —   | —  | —  | —  | —  | Understand effects of increasing max green time on intersection operations |

<sup>21</sup> Table reproduced from Shane Brown, Chelsea Nicholas, Michael Kyte, Evaluating The Effectiveness Of Dynamic Traffic Animations: A Case Study In Transportation Engineering Education, Journal of Professional Issues in Engineering Education and Practice, American Society of Civil Engineers, in press.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

**Table 11. Participants in the comparative case study**

| Case                                  | A                                  | B                          | C                               | D                             |
|---------------------------------------|------------------------------------|----------------------------|---------------------------------|-------------------------------|
| University                            | University of Idaho (UI)           | University of Idaho (UI)   | Portland State University (PSU) | Oregon State University (OSU) |
| Number of undergraduate participants  | 18                                 | 4                          | 0                               | 7                             |
| Number of graduate participants       | 0                                  | 2                          | 7                               | 8                             |
| Evaluation methodology                | One-on-one pre and post interviews | One-on-one post interviews | One-on-one post interviews      | One-on-one post interviews    |
| Exposure to animations and activities | Maximum exposure                   | Minimal exposure           | Minimal exposure                | No exposure                   |

**Table 12. Sample pre- and post- interview questions<sup>22</sup>**

| PRE   | POST  |
|---|---|
| <ul style="list-style-type: none"> <li>• What is the purpose of a signalized intersection?</li> <li>• How does the timing of a signalized intersection work?</li> <li>• What should the time the green interval is displayed be based on?</li> <li>• How does the controller decide when to terminate the phase?</li> <li>• What do you know about detection at intersections?</li> <li>• What is the effect of long cycle lengths at a signalized intersection compared with a short cycle length?</li> <li>• What does it mean to say a phase terminates too early?</li> <li>• If a phase terminates too early or extends too long, what solutions should be considered?</li> <li>• How do you determine optimum cycle length? What problems, if any, occur if the initial queue does not clear?</li> <li>• What are some indicators of inefficient intersection operations?</li> </ul> | <ul style="list-style-type: none"> <li>• What does it mean to say you have actuated control? What about an isolated intersection?</li> <li>• What is the purpose of the passage time?</li> <li>• Describe the relationship between passage time and maximum allowable headway.</li> <li>• If the passage time is set lower/higher than optimal what will happen?</li> <li>• What is the detection zone length in the video?*</li> <li>• How does each phase terminate in the video?*</li> <li>• If a phase terminates too early or extends too long, what solutions should be considered?</li> <li>• Describe the relationship between cycle length and delay.</li> <li>• What is the purpose of setting a minimum green time?</li> <li>• What problems, if any, occur if the initial queue does not clear?</li> <li>• What are some indicators of inefficient intersection operations?</li> <li>• Show the value of each timing parameter in the form of a chart for the given detector status.</li> </ul> |
| *These post-interview questions utilized videos.  |   |

<sup>22</sup> Table adapted from Shane Brown, Chelsea Nicholas, Michael Kyte, Evaluating The Effectiveness Of Dynamic Traffic Animations: A Case Study In Transportation Engineering Education, Journal of Professional Issues in Engineering Education and Practice, American Society of Civil Engineers, in press.

Interview data from student participants indicated that students with maximum exposure to the animations and activities had equal or greater understanding of traffic signal timing concepts compared with students who did not have this same exposure. Table 13 shows the results for each case and student responses to the concepts that were presented:

**Table 13. Summary of results of conceptual understanding of concepts for all cases<sup>23</sup>**

| Concept 1: Duration of the green indication - Animations <i>more</i> effective than other methods  |   |                                |                              |                              |                                |
|--|---|--------------------------------|------------------------------|------------------------------|--------------------------------|
| Case A - Pre   |   | Case A - Post                  | Case B - Post                | Case C - Post                | Case D - Post                  |
| 2/16 conceptual understanding  | ☑ | 8/16 conceptual understanding  | 2/6 conceptual understanding | 1/7 conceptual understanding | 2/15 conceptual understanding  |
| <ul style="list-style-type: none"> <li>Pre interviews: a light should stay green until no more cars are coming and a phase extends too long if green time is not being used</li> <li>Post interviews: a phase extends too long if the gaps between vehicles becomes too large or the <i>initial</i> queue has cleared</li> <li>Non-MOST students: a phase extends too long if green time is unused...Student 12 "if it was a green light and it seemed like no cars were coming, drivers on other approaches would get impatient. It'd be like, 'Why isn't it changing because there are no vehicles coming?'"</li> </ul>  |   |                                |                              |                              |                                |
| Concept 2: Cycle length and delay – Animations <i>as</i> effective as other methods  |   |                                |                              |                              |                                |
| Case A - Pre   |   | Case A - Post                  | Case B - Post                | Case C - Post                | Case D - Post                  |
| 8/16 conceptual understanding  | ☑ | 13/16 conceptual understanding | 5/6 conceptual understanding | 6/7 conceptual understanding | 11/15 conceptual understanding |
| <ul style="list-style-type: none"> <li>Pre interviews: most could explain that long cycle length = long delay</li> <li>Post interviews: most explained long cycle or short cycle = long delay</li> </ul>   |   |                                |                              |                              |                                |
| Concept 3: Passage time - Animations <i>as</i> effective as other methods  |   |                                |                              |                              |                                |
| Case A - Pre   |   | Case A - Post                  | Case B - Post                | Case C - Post                | Case D - Post                  |
| 0/16 conceptual understanding  | ☑ | 16/16 conceptual understanding | 4/6 conceptual understanding | 6/7 conceptual understanding | 13/15 conceptual understanding |
| <ul style="list-style-type: none"> <li>Pre interviews: few mentioned it, nobody described how it works. All knew how actuated was different than pre-timed</li> <li>Post interviews: knew how it works and how this parameter affects overall phase termination by explaining it relationship to other variables and explaining how it can be adjusted for phases that terminate at suboptimal times</li> </ul>  |   |                                |                              |                              |                                |
| Concept 4: Minimum green time - Animations <i>more</i> effective than other methods  |   |                                |                              |                              |                                |
| Case A - Pre   |   | Case A - Post                  | Case B - Post                | Case C - Post                | Case D - Post                  |
| 0/16 conceptual understanding  | ☑ | 13/16 conceptual understanding | 3/6 conceptual understanding | 4/7 conceptual understanding | 4/15 conceptual understanding  |
| <ul style="list-style-type: none"> <li>Pre interviews: few mentioned it, thought of as a minimum bound on green time for a phase. All knew how actuated was different than pre-timed</li> <li>Post interviews: could articulate its purpose (allow vehicle start up time or satisfy driver expectations).</li> <li>Non-MOST students: several thought pedestrian crossing time should be considered when setting a minimum green time. This is true only in special cases.</li> </ul>  |   |                                |                              |                              |                                |
| Concept 5: Maximum green time - Animations <i>more</i> effective than other methods  |   |                                |                              |                              |                                |
| Case A - Pre   |   | Case A - Post                  | Case B - Post                | Case C - Post                | Case D - Post                  |
| 0/16 conceptual understanding  | ☑ | 14/16 conceptual understanding | 3/6 conceptual understanding | 3/7 conceptual understanding | 4/15 conceptual understanding  |
| <ul style="list-style-type: none"> <li>Pre interviews: few mentioned it, thought of as a maximum bound on green time for a phase. All knew how actuated was different than pre-timed</li> <li>Post interviews: students knew how the maximum green timer works which implies an understanding of its purpose (starting once a call is placed on a conflicting phase so no vehicle has to wait too long on red)</li> <li>Non-MOST students: thought the maximum green timer starts counting down at the start of a phase which is in line with preconception that maximum green time is merely an upper bound and indicated that students do not understand the true purpose of setting a minimum green time</li> </ul> |   |                                |                              |                              |                                |

<sup>23</sup> Table adapted from Shane Brown, Chelsea Nicholas, Michael Kyte, Evaluating The Effectiveness Of Dynamic Traffic Animations: A Case Study In Transportation Engineering Education, Journal of Professional Issues in Engineering Education and Practice, American Society of Civil Engineers, in press.

Conceptual change was observed with students who received extensive exposure to the signal timing animations for all five concepts; duration of the green indication, the relationship between cycle length and delay, passage time, minimum green time, and maximum green time. Students across all cases had similar understandings of the relationship between cycle length and delay as well as the concept of passage time. This means the animations are no more effective than methods used in comparison groups. However, for the other three concepts the animations were shown to be more effective than current teaching techniques. Misconceptions regarding minimum green time and maximum green time that were seen across students who were not exposed to the animations were not present in students who did view the animations. Additionally, students who were exposed to the animations gave more complete or contextualized responses to questions dealing with the duration of the green indication than the other students.

It is likely that preconceptions played a significant role in learning the three concepts where students saw additional benefits from the animations and associated curriculum. Students have developed strong ideas about how signalized intersections work from years of driving experience. There are significant differences between the perceptions of drivers and those of traffic engineers when thinking about signalized intersections. Not all notions will transfer and if not addressed head on, students will develop misconceptions. The animations explicitly show students the effects of each timing parameter and variable so they can pick out what is relevant and what needs to be accounted for when evaluating an intersection. For example, when asked about factors to consider when setting a minimum green time students who did not receive extensive exposure to the animations listed several items. Some were correct, but more often than not there were additional factors listed that were not relevant including pedestrian crossing time. The students who worked through an activity in lab that was designed to investigate the purpose of setting a minimum green time gave the most supported response with no additional, irrelevant add-ons.

### **Portland State University Course**

A concept inventory associated with transportation data analysis was given at two points in the Portland State University course (at the beginning and at the end of the course) to assess the effects of the course on student understanding. These inventories provided a means to investigate the way in which students reasoned and thought about key concepts. The statistical concepts inventory utilized ten questions based on Allen<sup>24</sup>.

Table 14 shows pre- and post- assessment scores for ten of the students in the class. Of this group, six students showed improvement by end of the class. Only one student showed a decrease between pre- and post- test scores. The remaining three students showed no change in overall scores between the pre- and post- test scores.

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<sup>24</sup> Allen, Kirk. (2006). *The Statistics Concept Inventory: Development and Analysis of a Cognitive Assessment Instrument in Statistics*. (Ph.D.), University of Oklahoma, Norman, OK.

Table 14. Concept inventory results

| Question                               | Change |
|--|--------|
| 1. Two sample tests                    | Down   |
| 2. Effect of max and min on median     | Up     |
| 3. Effect of outliers on statistics    | Up     |
| 4. Confidence interval definition      | Up     |
| 5. Confidence interval and sample size | Up     |
| 6. Standard deviation sign             | Up     |
| 7. Statistical graphs and diagrams     | Up     |
| 8. Probability distributions           | Down   |
| 9. p-value and hypotheses              | Up     |
| 10. Box plots and distributions        | Up     |

Overall these results are positive. The lack of consistent and marked improvement may be because of the link between course content and concept questions. The concept questions were from the statistical concepts inventory relating to general statistics concepts. However, these questions are not all directly linked to course concepts and students, therefore, may not have improved their understanding of these more general statistical concepts.

Students were also provided an opportunity to explain their thought process through open-ended questions after each problem statement. Generally, the written responses differ between pre- and post- test explanations in that post-test explanations showed greater confidence in defending their answers.

#### University of Washington Course

Pre- and post- course surveys consisting of 10 questions regarding the freight system, freight modeling, and current issues within freight transport were used to measure student understanding in the University of Washington course. Sixteen students completed the pre-course survey, and 11 students completed the post-course survey. The results of the survey indicated that students become more knowledgeable after taking the course. See Table 15 and Table 16.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

**Table 15. Student Responses in Pre- and Post- Course Surveys (Concept-related questions)**

| Course Concept   | Observation of Pre-Course Results  | Observation of Post-Course Result  | Change in Understanding |
|--|--|--|-------------------------|
| Drawing the freight system   | "In the pre-course survey, many students drew what is essentially a supply chain, showing the movement of a good from producer to customer, which is perhaps what most lay people think of when they consider a freight system, but overlooked components of infrastructure/facilities and management/ overseeing agencies, which are important parts of the system" | "In the post-course survey, students still drew what is essentially a supply chain, showing the movement of a good from producer to customer and the <b>responses were less sophisticated than in pre-survey.</b>  | Negative                |
| Modes of transport   | "... in the pre-course survey, all students correctly identified the primary modes and many (but not all) students could correctly rank in terms of cost and speed (occasionally slight confusion regarding rankings in the middle, but understood trends). About half of the students could correctly rank by volume."  | "In the post-course survey <b>all students correctly identified the primary modes and could rank unit cost and speed correctly.</b> About half of the students could correctly rank by volume. Ranking by volume is the most difficult because while there are general trends, there are also exceptions to the trends."               | Positive                |
| Factors influencing choice of modes within freight transport       | "In the pre-course survey 3 students listed 1 factor, 7 students listed 2 factors, 5 students listed 3 factors, and 1 student listed 4 factors."   | "In the post-course survey 2 students listed 1 factor, 6 students listed 3 factors, 2 students listed 6 factors, and 1 student listed 7 factors. Generally, <b>students listed more factors in the post-course survey which shows that they have greater insight into the issues surrounding freight transportation.</b> "             | Positive                |
| Comparison between passenger vehicle modeling and freight modeling | "While 3 people said I don't know in the pre-survey and there were no I don't know answers in the post-survey, 2 of the pre-course survey respondents did not take the post-course survey."  | "In both the pre and post course evaluations, students gave reasonable answers and it is difficult to determine if knowledge was gained throughout the course. Several students also answered with a personally influences response – that they were not really concerned about passenger vehicle modeling because they didn't drive." | Neutral                 |

Table 16. Student Responses in Pre- and Post- Course Surveys (Concept-related questions) (continued)

| Course Concept                      | Observation of Pre-Course Results   | Observation of Post-Course Result  | Change in Understanding |
|-------------------------------------|---|--|-------------------------|
| Identifying Vehicle Routing Problem | <p>“Only 3 students knew the name of the method before the course...”</p> <p>“In the pre-survey, several students could describe correctly even if did not know the name, one student specified that they learned about this in other classes.”</p> | <p>“...which increased to 5 after”</p> <p>“In the post-survey those with incomplete method were often describing what we did in class but not describing how it worked. Regardless, students had a greater understanding of the VRP after taking the class.”</p> | Positive                |
| Operation of the Port of Seattle    | <p>“The number of students who left this question blank or indicated that they did not know dramatically decreased from the pre survey (7 students)...”</p>   | <p>“...to the post survey (1 student).”</p>  | Positive                |
| The effects of containerization     | <p>Students were asked how containerization impacts freight transportation and the <b>results indicate that students appeared to have a good understanding of containerization both before and after the course.</b></p>                            |  | Neutral                 |

The effects on student learning were mixed, partially due to the choice of concepts that were assessed.

### Summary

In nearly all cases students improved their understandings of key concepts in the three participating courses. The most detailed information on student learning was gathered for the University of Idaho course. In this case the learning outcomes were directly mapped to the assessment and students showed substantial improvement on their understanding of all concepts. The active learning environment using the simulation software was effective on student learning. Results from Portland State University were less definitive. However, as mentioned above this is likely attributed to the concept inventory measuring concepts that were not explicitly covered in the course. Finally, University of Washington students generally improved their conceptual understanding with two concepts showing no change and one concept where students showed a decreased understanding. Similar to the University of Idaho assessment effort, these concepts were directly mapped to the course learning outcomes. Substantial evidence from educational research shows that courses often have minimal impact on students' conceptual understanding<sup>25 26</sup>. Therefore the general improvement of conceptual

<sup>25</sup> Krause, S, Decker, J. C., & Griffin, R. F. “Using a materials concept inventory to assess conceptual gain in introductory materials engineering courses”, presented at the Frontiers in Education conference, 2003.

understanding noted in the participating courses is positive. The participating courses were successful in changing students' understanding of core concepts.

### 4.4 Evaluation of Developed Materials

An evaluation workshop was held in August 2012 with the purpose of gathering feedback from other transportation engineering faculty and professionals on the materials and methods developed as part of this project.

In addition to the project team members, fourteen faculty and professionals not directly involved in the preparation of the course materials attended the workshop. At the workshop, activities were presented by each of the four participating universities or others who had experience in using the activities. The activities were presented in an authentic manner so that feedback could be gathered both on the activity itself and the implementation of the activity. After the activity was presented, feedback was solicited through open-ended questionnaires and through group discussions. This section presents the strengths of the activities, suggested improvements, and other insights suggested by the reviewers.

#### University of Idaho Example Activity

Two example activities from the University of Idaho course on traffic signal timing were presented by an instructor who had used earlier versions of the activities in his classes. The activities were introductory in nature, designed to provide students with insights about traffic flow on arterials and simulation modeling.

The strengths of these activities, as discussed by participants during the large group discussions, included:

- The activity related physical and simulated problems to real-world situations with its use of video and computer simulations
- The video activity demonstrated the vast amount of data to be collected by transportation engineers
- The video and simulations provided an opportunity to visualize conditions as they would be in the field, as opposed to just static diagrams or text
- Whoever develops the video or simulation can control what students see or focus on when trying to solve real-world problems
- The activity provided a prompt for further discussion and exploration
- Several participants noted that the video realistically resembled the vision of an individual going through the intersections.

Some of the improvements suggested for the activity included:

- Shorter (e.g. 15 second clips) lengths of video
- Video from the driver perspective (as opposed to passenger perspective)

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<sup>26</sup> Richardson, Jim, Morgan, Jim, & Evans, Don. (2001). Development of an Engineering Strength of Material Concept Inventory Assessment Instrument. Paper presented at the ASEE/IEEE Frontiers in Education Conference, Reno, NV.



- Side-by-side illustration of location (via GPS on a map) relative to the video
- Providing different perspectives along the same intersections
- Instead of a driver or passenger perspective, utilize a fixed position for the camera
- Providing greater scope of the situation by increasing to a wider angle for both the simulation and video
- The precision of questions may encourage more directed thought processes from the students
- A greater structured use of time may assist in facilitating the activity

Some insights of participants included:

- Several participants noted that more emphasis on the fact that simulations do not represent exact situations was needed to ensure students are not exiting the class believing that all simulations end up looking exactly like real life
- The activity, as noted by one of the participants, still seemed faculty-centered as opposed to student-centered
- The issue of the deliverables of students was also discussed. Do students turn in a write-up of the activity?

Reviewers were provided questionnaires to provide deeper insight into their individual experiences with the activities. Themes were identified within the open-ended questionnaires. The number of participants identifying the themes is noted in parenthesis. The results are presented in Table 17.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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**Table 17. Activity assessment, University of Idaho**

|   |
|---|
| In your opinion what are the target outcomes of this activity?  |
| <ul style="list-style-type: none"> <li>• Introduction to arterial intersections and timing of signals (15)</li> </ul>   |
| What prerequisite knowledge is necessary to complete this activity?   |
| <ul style="list-style-type: none"> <li>• Definitions of traffic engineering terms (5)</li> <li>• Basic traffic signal operation (8)</li> </ul>                        |
| In what ways was the activity effective/ineffective?  |
| Effective:  |
| <ul style="list-style-type: none"> <li>• Helping students to understand traffic operations concepts or how they are applied in real world applications (8)</li> </ul> |
| Ineffective:  |
| <ul style="list-style-type: none"> <li>• A lot of information to observe (4)</li> <li>• Questions could be more clear (2)</li> </ul>                                  |
| What parts of the sample activity will students find most interesting?  |
| <ul style="list-style-type: none"> <li>• Video simulation presentation (13)</li> <li>• Recording observations and discussing them (4)</li> </ul>                      |
| What part of the sample activity will students find most challenging?   |
| <ul style="list-style-type: none"> <li>• Recording observations and discussing them (6)</li> <li>• Recording the data (7)</li> </ul>                                  |
| What aspects of the sample activity are the easiest for faculty to use?   |
| <ul style="list-style-type: none"> <li>• Videos and discussion (10)</li> </ul>  |
| What aspects of facilitating the sample activity will be most challenging for faculty?  |
| <ul style="list-style-type: none"> <li>• Directing students to see what is relevant (9)</li> <li>• The activities might not fit into time slot (7)</li> </ul>         |
| In what ways is the packaging of these curriculum materials appealing/intuitive to potential users?   |
| <ul style="list-style-type: none"> <li>• Video was well done (3)</li> <li>• Material is easily adoptable (13)</li> </ul>  |

### Portland State University Example Activity

One activity was presented by the Portland State University instructor for review, the main concept of which was graphical representations of data and understanding how to explore data for outliers, missing data, and other issues. The instructor provided background (via a short lecture) prior to distribution of activity materials.

The strengths of this activity, as discussed by participants, included:

- The activity emphasized that presentation of data affects interpretation
  - Related to this, another participant noted that the activity's introduction of a human element provided students the opportunity to understand how human judgment can affect final data interpretation
  - Another participant noted that a "theme of perception" lay within the entire activity
- The fact that students created the data set themselves, provided a common experience and ownership of the data
- Another participant noted that the activity was not complicated with extraneous data or functions. It enabled students to focus on the subject and concept at hand.
- A participant noted that the activity provided opportunity for critical thinking on a subject that can sometimes be taken for granted within the field.

Some of the improvements suggested for the activity included:

- A participant noted greater focus on concepts prior to the actual activity may be helpful for student understanding.
- Another participant suggested provision of real-world context by asking, "how can this data be transferred to the real world?"
  - Other participants noted more clarity and providing context may improve the activity; this could be done by providing context of drawings/graphs (as suggested by one of the participants)

Some insights of participants included:

- Several participants suggested the use of I-clickers, instant text messaging software, and other online tools to gather real-time student response to question

Themes were identified within the open-ended questionnaires as noted in Table 18. The number of participants identifying the themes is noted in parenthesis:

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

**Table 18. Portland State University, activity assessment**

|  |
|--|
| <p>In your opinion what are the target outcomes of this activity?</p> <ul style="list-style-type: none"> <li>• Get students to understand that data is interpreted differently based on how it is perceived (10)</li> <li>• See how different ways to visualize/graph something are better than others (8)</li> </ul>  |
| <p>What prerequisite knowledge is necessary to complete this activity?</p> <ul style="list-style-type: none"> <li>• Basic stats (10)</li> <li>• Knowledge of graphs (2)</li> </ul>   |
| <p>In what ways was the activity effective/ineffective?</p> <p>Effective:</p> <ul style="list-style-type: none"> <li>• Looking at the different plots will make students think beyond what is obvious (3)</li> <li>• Showing different data representations and facilitating comparisons (5)</li> </ul> <p>Ineffective:</p> <ul style="list-style-type: none"> <li>• Didn't talk much about power of R</li> <li>• Can lead to a misleading conclusion</li> </ul> |
| <p>What parts of the sample activity will students find most interesting?</p> <ul style="list-style-type: none"> <li>• Comparing methods and results with each other (6)</li> <li>• Seeing their results and how they relate to plots (7)</li> </ul>   |
| <p>What part of the sample activity will students find most challenging?</p> <ul style="list-style-type: none"> <li>• Figuring out how to take, use, and present data (5)</li> <li>• How to effectively understand data plots (5)</li> </ul>   |
| <p>What enduring understanding is likely to result from sample activity?</p> <ul style="list-style-type: none"> <li>• Graphs can be useful but must be in the right format (6)</li> <li>• Students should continue to think about effectiveness and appropriateness of data representation and manipulation (11)</li> </ul>  |
| <p>What aspects of the sample activity are the easiest for faculty to use?</p> <ul style="list-style-type: none"> <li>• All materials are laid out for you (10)</li> </ul>   |
| <p>What aspects of facilitating the sample activity will be most challenging for faculty?</p> <ul style="list-style-type: none"> <li>• Must know how to use R (4)</li> <li>• Lots of data entry (6)</li> </ul>   |
| <p>In what ways is the packaging of these curriculum materials appealing/intuitive to potential users?</p> <ul style="list-style-type: none"> <li>• Materials were good and showed the concepts/results well (3)</li> <li>• Collecting and making sense out of their own data (3)</li> </ul>   |

### University of Washington Example Activity

One activity on freight modeling was presented by the University of Washington instructor. The main resource for this activity was the Freight Analysis Framework (FAF3) Origin-Destination Data website provided by the Federal Highway Administration. Participants were asked to work in groups to complete the activity. However, the original activity (as designed for students taking the course) required students to work alone with individual access to the website.

The strengths of the facilitation of this activity, as discussed by participants, included:

- There existed a “good mix of instruction and exploration” for the participants.
- The tools and references were readily accessible online.
- The online tools and the activity designed around the tools created opportunity for quick feedback.

- The overall problem, which was complex, was structured in a way that was easily understandable and manageable.
- The activity utilized practical data source for freight.
- Another participant noted that the national data set provided context for students.

Some of the improvements suggested for the activity included:

- Certain portions of the activity were not always engaging, according to several participants.
  - One participant proposed that this activity be presented as a game.
  - Another participant suggested that during the downtime, the facilitator either give specific jobs to students or provide prompts for further discussion.
- Several participants suggested different forms which this activity could be presented:
  - One participant suggested formatting this activity as a ranking task
  - Another suggested presenting it as a “jigsaw activity” (i.e. having the data sets fit to form a final product)
- A participant suggested that a primer introducing the final goal and objectives of the activity be provided to the students.
- Another participant suggested that the facilitator ask students to formulate their own questions as part of the activity.
- Several participants noted that providing real-world context may assist students to understand the use of the online tools and data set. A participant suggested tying the data gathered by students to transportation engineering and its implication to policies (political, social, etc.).

Some insights of participants included:

- A weakness (in terms of the online resource) is that the data set is dependent on someone else. The reliability of the data could be questioned.
  - One of the participants countered that this was the most reliable data set provided as open-source.
- Some participants noted opportunity for rewarding tools associate with this activity:
  - The use of sporadic grading, random calling, use of “clickers”, etc. may increase active participation amongst students.
  - There were debates regarding the effectiveness of these various reward tools amongst participants.

Themes identified in the open-ended questionnaires indicate several patterns (see Table 19). As noted previously, the number of participants identifying themes is noted in parenthesis. The majority of themes identified in the questionnaires address the actual tool utilized during the activity and the data sources available within freight transportation. The group discussion was limited to strengths, suggested improvements, and insights relating to the facilitation of the activity, as opposed to the design of the activity.

**Table 19. University of Washington, activity assessment**

|  |
|--|
| <p>In your opinion what are the target outcomes of this activity?</p> <ul style="list-style-type: none"> <li>• Learn about freight analysis framework (FAF) as a tool (11)</li> <li>• Get an understanding of freight flow (7)</li> <li>• Become aware of the data source (3)</li> </ul>   |
| <p>What prerequisite knowledge is necessary to complete this activity?</p> <ul style="list-style-type: none"> <li>• Basic knowledge on the definitions of import/export (3)</li> <li>• Basic Geography (2)</li> <li>• Freight modeling (2)</li> <li>• Data sources and limitations (1)</li> </ul>  |
| <p>In what ways was the activity effective/ineffective?</p> <p>Effective:</p> <ul style="list-style-type: none"> <li>• Website was a good tool (2)</li> <li>• Tool was easy to use (2)</li> <li>• Allow students to explore freight movements (2)</li> </ul> <p>Ineffective:</p> <ul style="list-style-type: none"> <li>• Capacity limit on online users</li> <li>• Might have some disengaged students if not orchestrated correctly (2)</li> <li>• Having one person drive while the rest watch</li> </ul> |
| <p>What parts of the sample activity will students find most interesting?</p> <ul style="list-style-type: none"> <li>• Learning more about data (4)</li> <li>• Comparing values and results with each other (2)</li> </ul>   |
| <p>What part of the sample activity will students find most challenging?</p> <ul style="list-style-type: none"> <li>• Staying focused while someone else uses the pc (4)</li> <li>• Understanding the website and questions (4)</li> </ul>   |
| <p>What enduring understanding is likely to result from sample activity?</p> <ul style="list-style-type: none"> <li>• What data is out there and what are its limitations (6)</li> <li>• There are multiple ways to approach problems and maybe multiple solutions (2)</li> </ul>  |
| <p>What aspects of the sample activity are the easiest for faculty to use?</p> <ul style="list-style-type: none"> <li>• Tools are online and already made (5)</li> <li>• Material is easy to use and accessible (4)</li> </ul>   |
| <p>What aspects of facilitating the sample activity will be most challenging for faculty?</p> <ul style="list-style-type: none"> <li>• Keeping students engaged (7)</li> <li>• Making the data relevant to specific areas and forming questions around it (4)</li> <li>• Helping students understand data (2)</li> </ul>   |
| <p>In what ways is the packaging of these curriculum materials appealing/intuitive to potential users?</p> <ul style="list-style-type: none"> <li>• Online material is very accessible (6)</li> <li>• Easily deployable (2)</li> </ul>   |

### University of Alaska Example Activity

The University of Alaska instructor presented an activity that was part of the Rural Highway Design and Safety course. The main concept of the activity was geometric design (specifically, horizontal curvature, superelevation, and balancing cut/fill volumes).

The instructor provided participants (placed in four different groups) materials (large, scaled, topographical drawings of a site, measuring equipment, markers, etc.) to be utilized in solving a design problem he posed. Prior to letting the participants work on the design, the instructor

provided a lecture describing the concepts and associated engineering standards. After a short lecture, he asked participants to propose an improved roadway alignment for a specified site.

The instructor assigned roles to participants within each group (i.e. two designers, two analysts, and one general manager per group). Lastly, during the discussion of strengths, suggested improvements, and insights he noted that his students actually utilized the same drawing throughout the entirety of the course, which provided longitudinal understanding of the design process.

After completing the activity, fellow faculty members and participating graduate students discussed some strengths, insights, and possible improvements regarding the activity. The strengths of the design and facilitation of this activity, as discussed by participants, included:

- Several participants noted the good quality of the materials (the size and level of detail provided by the scaled site drawing on which participants drew their respective designs, the provided tables and graphs).
- Another strength was that the activity encouraged discussion amongst students, as well as the instructor.
- The level of complexity of the activity was also mentioned as a strength of the activity design.
  - One participant noted that the activity provided opportunity to discover “unmentioned limitations and possibilities” associated with designing a roadway and attempting to address the stated problem.
- Several individuals noted that the assignment of roles within each group fostered structure relationships.
  - Note: This topic was discussed at length due to several participants arguing that the assigned roles created unbalanced workloads amongst group members. One comment noted that the project manager and analysts did not really have anything to do until the designers completed their portion of the activity.
- An argument for the assignment of roles was that it held students accountable for specific responsibilities associated with the role.
- Several participants also noted that the presentation of materials seemed well organized.
- Others noted that they (as participants) felt engaged in the activity

Some of the improvements suggested for the activity included:

- A participant noted that the measurement for effectiveness was vague. He noted that, as a participant, he was not quite sure “what made for a good alignment.”
  - Clearly stating the measures associated with design prior to the actual activity may provide greater guidance for participants.
- The task at hand was somewhat vague, according to one of the participants.
  - The participant suggested that the first task (e.g. figuring out the route) should be stated.
- An improvement in facilitation included telling students about “uncertainty” and its role in engineering design prior to the activity.

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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Some insights of participants included:

- One of the participants noted that the manual drafting associated with this exercise may seem foreign to students used to working with computer-based drafting systems.
- As a general observation, one participant noted that the activities associated with the course “seemed like a lot to do within time constraints.”
- Another participant noted that equipment requirements associated with printing out large-scale drawings may limit who can and cannot replicate this activity.

The difficulty and open-endedness of the project appear to be just right. For example, in the University of Alaska activity some participants suggested that this problem was not constrained enough, it was difficult to get started, and there were too many different solutions. In contrast some participants suggested the UW activity was too defined and constrained. It is extremely challenging to get this right the first time so the continuous improvement approach to activity development is essential to successful development and implementation over time.

The open-ended questionnaires generated several themes (see Table 20). The bulleted list shows some of these general patterns. Numbers within the parenthesis indicate number of times the statement was made in the open-ended questionnaires.



**Table 20. University of Alaska, activity assessment**

|   |
|---|
| <p>In your opinion what are the target outcomes of this activity?</p> <ul style="list-style-type: none"> <li>• Understanding of horizontal curves and different elements in geometric design (6)</li> <li>• Team building and critical thinking (4)</li> </ul>  |
| <p>What prerequisite knowledge is necessary to complete this activity?</p> <ul style="list-style-type: none"> <li>• Understanding highway design elements (6)</li> <li>• Some Understanding of roadway design principle concepts and terms (6)</li> <li>• In depth Greenbook background (3)</li> </ul>  |
| <p>In what ways was the activity effective/ineffective?</p> <p>Effective:</p> <ul style="list-style-type: none"> <li>• Teamwork is good for students (8)</li> <li>• Hands on experience is great (5)</li> <li>• The process gives a much better understanding of the elements involved in designing curves (6)</li> </ul> <p>Ineffective:</p> <ul style="list-style-type: none"> <li>• Multiple hidden constraints of adjacent curves added</li> <li>• Realism and feedback to alternative selection</li> <li>• Clarifying roles for students</li> <li>• It was too long /weren't too many different elements</li> <li>• Vertical alignment is ignored</li> </ul> |
| <p>What parts of the sample activity will students find most interesting?</p> <ul style="list-style-type: none"> <li>• Real world example to apply what they learn from basic design principles (9)</li> <li>• Analysis of various design choices (3)</li> </ul>  |
| <p>What part of the sample activity will students find most challenging?</p> <ul style="list-style-type: none"> <li>• The complexity of developing the solutions including understanding and applying design principles in an optimal way (3)</li> <li>• All of the calculations (6)</li> </ul>   |
| <p>What enduring understanding is likely to result from sample activity?</p> <ul style="list-style-type: none"> <li>• Good understanding of the complexity of roadway design and how to address the design (5)</li> <li>• Not every problem is cookie cutter out of a book (3)</li> <li>• Safety requirements (2)</li> </ul>  |
| <p>What aspects of the sample activity are the easiest for faculty to use?</p> <ul style="list-style-type: none"> <li>• The project materials would be easy to adopt (5)</li> </ul>   |
| <p>What aspects of facilitating the sample activity will be most challenging for faculty?</p> <ul style="list-style-type: none"> <li>• Ensuring teams stay on task and everyone contributes (4)</li> <li>• Lots of supplies and papers to print out (3)</li> <li>• Ensuring that all students have an understanding of the material (3)</li> </ul>  |
| <p>In what ways is the packaging of these curriculum materials appealing/intuitive to potential users?</p> <ul style="list-style-type: none"> <li>• Hands on will help students relate this to a job</li> </ul>   |

## 4.5 Instructors Self-Reflections

### University of Idaho Course

The instructor for the University of Idaho class noted that “...an assessment is a very personal process of reflection on how someone is doing. It is helping someone learn how they are doing, validating the positive aspects of what they are doing, and being clear on what things they can or need to do better. Here are my personal interpretations of what I learned in reading through the assessment results:”

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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- The activity-based learning format works very well for many (most) of the students and students are aware of this.
- Some activities are perceived as busy work for some students; can I more effectively describe the process that I want them to go through in learning the material and why? Can I better show relevance to their learning process?
- I need to more effectively close the loop in their learning process by going over their results, from both the reading assignments to the extensive design and lab activities, so they can validate what they learned or make corrections as needed. This includes reviewing VISSIM runs and results, discussing the answers to critical thinking questions, and reviewing homework examples and solutions.
- I need to link the field activities more clearly to the other activities, especially clarifying that the field conditions that they observe are different that the conditions that they “see” in their simulation work.
- The early activities (some in chapter 1 of the activity book) may seem trivial and may need to be re-examined.
- The team agreements should be revisited during the semester to validate its usefulness and relevance.
- Concept maps have potential to increase student learning, especially in “gathering together” the concepts that have been learned within a given topic or chapter. I need to integrate concept maps into the class process.
- I need to more effectively show how all of the activities fit into the design process: there is a progression within each chapter and there is a progression with each of the design activities that lead to the final design project.

### Portland State University Course

The Portland State University instructor provided several personal observations regarding his process and the development of the course. He noted that the course design approach was useful. The activity based approach was enjoyable for him to teach. The work up front was a bit heavier than traditional courses. He suggested avoiding the development of an entire course at once. Rather, he suggested adding individual activities to existing courses. He also warned other faculty members about excessive amount of feedback from students using this teaching methodology. Finally, he noted that traditional exams did not work in this course.

### University of Washington Course

The instructor for the University of Washington course noted several insights regarding the course:

- Casual groups organically formed amongst students during the course
- She did experience equipment and technology issues that affected activities
- During whole group discussions, she found that certain students dominated the conversation; she suggested that discussions amongst three or four people worked better within her class

### University of Alaska Course

The University of Alaska course instructor provided reflections on the course:

- He noted that the faculty members (those who participated in this particular activity) saw a different version of the activity than what his students encountered during the actual course.
- One difference was that students saw the entire existing alignment as opposed to just half of it.
- He also noted that the references he utilized for the activity (design controls and criteria) were resources which he already had access to, and he did not seek out other resources.

### 4.6 Summary and Discussion

There is substantial evidence that the classroom environments designed and implemented in this project were very interactive and motivating; that students worked on authentic open-ended design problems; and that students generally improved their conceptual understandings of core concepts in these courses. Student survey responses to questions about the opportunities to interact with the faculty and other students were positive. Students almost uniformly responded either sometimes, often, or very often to questions about how often they asked questions or shared ideas with faculty and students. Compared to a traditional lecture class, this is a dramatic difference. It is quite possible that a student could not ask a single question over the course of a term in a traditional lecture course.

The interactivity was especially evident in the August 2012 peer review workshop. During this workshop, instructors implemented an authentic version of a typical class activity. In every case the activities included substantial active learning, ranging from 50 to 75 % of the activity time. The active learning was very engaging, and the activities were challenging enough to require attention but also easy enough that they could generally be completed in the allotted time. Additional data come from the course assessment of the University of Idaho course. Students provided evidence that the group work was the most valuable and influential aspect of the course on both closed and open ended survey questions.

Survey responses and feedback from the workshop indicate the activities students worked on in these courses were authentic and open-ended. Students utilized authentic software (e.g., VISSIM in the University of Idaho course), designed authentic engineering facilities (horizontal and vertical curve design using engineering drawings at the University of Alaska), engaged with authentic data sets (freight data at the University of Washington course), and understood the real-world application of course content (interpretations of graphs at Portland State University).

Student learning improved as they generally improved their conceptual understanding of challenging core concepts. There were only a few cases where student understandings declined, and this can be attributed to the measure not being directly linked to the curriculum.

The inputs of this project were the design and implementation of an active, authentic problem-based curriculum at four unique universities. The expected outputs are the creation of a

## Development, Deployment, and Assessment of Activity-Based Transportation Courses

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learning environment conducive to productive interactions that results in students being motivated to learn, to practice their communication skills and their understanding of important concepts. The inputs were achieved, as judged by the previous sections of this report highlighting the extensive materials that were developed and implemented. The outputs were similarly achieved, as a result of the inputs. Students and peers responded favorably to the curriculum and the manner in which it was implemented. In summary this model is effective in achieving the desired outputs.

Achieving these outputs is not simple. Faculty reported several challenges in this project: students didn't always respond favorably to the environment, there is substantial work required, and the details of implementation are important to success. Additionally, offering this approach using distance technology provides new challenges. Despite these challenges, this project was successful in meeting its stated objectives.

## CHAPTER 5. RESULTS AND LESSONS LEARNED

This chapter presents a summary of the results generated from this project and the resulting lessons learned by the project team. The key results are summarized as presented in chapters 2, 3, and 4 of this report. The lessons learned that may be of interest to or helpful for transportation policy makers, educators, and practitioners are presented here.

### 5.1 Results

The Federal Highway Administration's Transportation Education Development Pilot Program provided the resources for the project team to develop four new transportation courses:

- Traffic Signal Systems Operations and Design
- Understanding and Communicating Transportation Data
- Introduction to Freight Transportation
- Rural Highway Design and Safety

The courses are learner-centered in which students work on activities in the classroom as opposed to solely listening to lectures from an instructor. The process used by the project team to design the courses included five elements: an analysis of the intended audience, a definition of the course environment, the course design, unit planning, and activity design. Course design documents that include these five elements were developed for each of the four courses. The courses were collectively offered a total of fourteen times between 2008 and 2012 to a total of 195 students. An activity book was developed for each of the four courses, including a total of 142 activities. The books and all supporting materials are available on the project web site.

A number of assessments and evaluations were conducted to determine how effective the courses and materials were in meeting project objectives. Students stated that they had substantial opportunities to actively participate in the active-learn environments that were created. Students stated that they were able to ask the instructor and other students questions, to work on open-ended authentic design problems, to practice and improve their written and verbal communication skills, and that the course content was interesting, useful and important. The active learning style was a challenge for many students, as they were required to be prepared for class and to do "active" work during class. In general, there was an acceptance of the value of active learning environments. The activity-based books provided students with a sound basis for understanding the key concepts, enhanced their learning and understanding of the key concepts, and allowed them to explore the factors that affect a design. In one of the courses, two-thirds of the students noted that they did most of their learning in classroom during group work. Conceptual understanding was heightened by the four courses and the active learning environments that were created.

The materials developed in this project are highly adoptable, as judged by some of the five characteristics of an adoptable innovation developed by Rogers<sup>27</sup> and tested by Sahin.<sup>28</sup> The

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<sup>27</sup> Rogers, Everett M. (2003). *Diffusion of Innovations* (5th ed.): Free Press.

<sup>28</sup> Sahin, I. (2006). Detailed review of Roger's diffusion of innovations theory and educational technology-related studies based on Roger's Theory. *Turkish Online Journal of Educational Technology*, 5(2).

learning activities are useable independently from other materials so they are “trialable.” They have descriptions of all the resources needed, making them relatively easy to implement, so they also have low “complexity.” They are arguably the only large set of learning activities for these topics, so they have high “relative advantage” in that they are better than the alternative. Three universities used the new materials from the Traffic Signal Systems Operations and Design Course in fall 2012, showing some early evidence of the adoptability of the materials.

One evaluator noted:

“I think what you have developed is highly transferable and adoptable because an instructor can take small pieces and implement them, as opposed to having to adopt a week or a month’s worth of materials. Also, the materials give information on what resources are needed and the instructor’s guides provide valuable insight on how to approach implementation. I think all of these things are really important outcomes of this project....i.e. it has been shown to work and is relatively easy to adopt. If I was teaching a course in this area I would absolutely go to you first for materials.”

### 5.2 Lessons Learned

A project like this is by its nature one in which the participants are continuing to learn. While the team had considerable previous experience in developing active learning materials, this project generated a number of lessons.

One of the most important lessons is the importance of developing the specifications that would be used to develop the course materials. All members of the team agreed that the time that it took to think through the elements that became the course design documents was invaluable. Without the framework that they provided and the insights that were gained in thinking through difficult issues, the final materials would not have been the high quality ones that were produced here.

It is also clear that making our educational system more learner-centered (with the instructor serving as a guide on the side and not a sage on the stage) is critical to improving outcomes for our students. But it is also clear that this reform will not come easy, nor will be it inexpensive. Traditional courses do not require students to be as prepared or as engaged, and as noted in the assessment and evaluation, they often push back against these changes. And, the cost of developing and testing new materials based on a new paradigm is not cheap, as evidenced by the budget provided for this project.

Finally, the team has spent a significant amount of time considering how the outcomes of this project can be transmitted to others who are interested in promoting new ideas in workforce development. We recommend the following ideas for consideration by FHWA. Non-traditional means of teaching and learning need wider distribution to both university faculty as well as instructors who deliver continuing education content. While STEM (science, technology, engineering and mathematics) research has shown that student-centered learning is without question the most effective approach for both university students as well as practicing professionals, most instructors in both forums continue to use the standard lecture format. We

feel strongly that FHWA, and other organizations that are concerned with improving the quality, skills, and abilities of our workforce, should continue to fund projects in which active-learning environments are promoted and supporting curriculum developed.

One example of what this project has already spawned is the National Transportation Curriculum Project (NTCP), a group of educators from around the U.S. that has worked together for more than three years to improve the first course in transportation taken by most civil engineering students. As a result of this current TEDPP project, the NTCP has developed a set of learning outcomes and knowledge tables for ten subject areas in transportation, including traffic operations, transportation planning, geometric design, transportation finance and economics, traffic safety, public transportation and non-motorized modes, human factors and driver behavior. The group has also made presentations of its work at meetings of the American Society of Engineering Education, the Institute of Transportation Engineers, and at meetings of the Transportation Research Board. This group is preparing new materials based on the ideas and templates developed in this current project.





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## APPENDIX. PROJECT WEB SITES AND MATERIALS

The project web site contains all of the materials produced for this project:

<http://transportationeducation.wordpress.com/>

The project web site also lists the individual web sites for each of the four courses. These web sites, as well as the university responsible for developing the course, the name of the course, and the name of the activity book are listed below.

### University of Idaho

- Course name: Traffic Signal Systems Operations and Design
- Activity book: “Traffic Signal Systems Operations and Design, Activity Based Learning, Book 1: Isolated Intersections”, Michael Kyte and Tom Urbanik, First edition, Pacific Crest, Plainfield, IL, 2012.
- Web site: <http://trafficsignalsystems.com/>

### Portland State University

- Course name: Understanding and Communicating Multimodal Transportation Data
- Activity book: “Understanding and Communicating Multimodal Transportation Data”, Chris Monsere, First edition, Pacific Crest, Plainfield, IL, 2012.
- Web site: <http://www.transportation-data.com/>

### University of Washington

- Course name: Introduction to Freight Transportation
- Activity book: “Freight Transportation – Activity Based Learning”, Kelly Pitera, First edition, Pacific Crest, Plainfield, IL, 2012.
- Web site: <http://www.freight-transportation-education.com/>

### University of Alaska

- Course name: Rural Highway Design and Safety
- Activity book: “Rural Highway Design and Safety – Activity Based Learning”, Ming S. Lee, Cindie Little, Billy Conner, First edition, Pacific Crest, Plainfield, IL, 2012.
- Web site: <http://www.ruralhighwaydesign.com/>

