TEAM APPROACH TO DEVELOPING ACTIVE LEARNING CURRICULUM

2012 ASEE PNW Pre-Conference Workshop

Mike Kyte, Dan Cordon, Steve Beyerlein – University of Idaho
Kelly Pitera – University of Washington
Ming Lee – University of Alaska

Workshop Outcomes:

1. **Increase motivation to do more thoughtful course design as a framework for selecting, creating, and validating course learning activities.**

2. **Define and describe the purpose and added value associated with each element in FHWA learning activities.**

3. **Validate a subset of assessment questions about course and activity design (for FHWA peer review this summer as well as participant use).**

4. **Generate interest in future ASEE PNW workshops on curriculum design, facilitation, and assessment for better student learning.**

Introductions: (be prepared to share)

- **Your name**
- **Your affiliation**
- **Courses you teach that involve active learning**
- **A best practice or concern about active learning that you want to explore**

Team Approach to Developing Active Learning Curriculum

2012 ASEE PNW Pre-Conference Workshop

University of Portland

15-March, 2012

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Workshop Agenda

6:00 Facilitator Introductions
Mike Kyte, Dan Cordon, Steve Beyerlein (Univ. of Idaho)
Kelly Pitera (Univ. of Washington)
Ming Lee (Univ. of Alaska)
Participant Introductions

6:10 FHWA Curriculum Project
FHWA Course Design & Activity Design Model

6:20 Case Study

6:35 Small Group Discussion of Case Study

7:05 Large Group Reporting of Discussion Results

7:20 Adjourn for PNW Business Meeting

Introductions

Take turns sharing:

Your name?

Your affiliation?

Courses you teach that involve active learning?

A best practice or concern about active learning that you want to explore?

FHWA Project

Transportation Education – Region X TEDPP

Activity-Based Learning for Transportation

Courses
- Freight transportation (at UW)
- Data analysis methods (at PSU)
- Geometric design/safety (at UA)
- Traffic signal systems design (at UI)

References

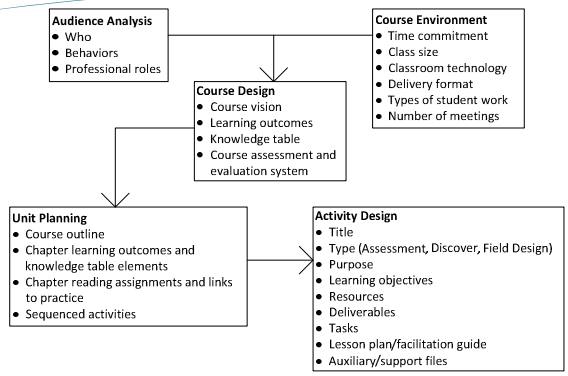
Fink (2003). Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses. San Francisco: Jossey-Bass.

Wiggins & McTighe (2005). Understanding by Design, 2nd Edition. Baltimore: Association for Supervision & Curriculum Development.

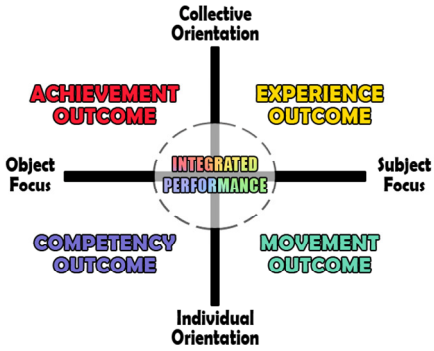
Beyerlein, Holmes, & Apple (2007). Faculty Guidebook: A Comprehensive Tool for Improving Faculty Performance, 4th Edition. Lisle, IL: Pacific Crest.

"Learning Outcomes" by Beyerlein, Davis, & Apple
"Forms of Knowledge and Knowledge Tables" by Quarless
"Designing Process-Oriented Guided-Inquiry Activities", by Hanson
"Facilitation Methodology", by Smith & Apple
"Creating a Facilitation Plan", by Minderhout
"Assessing Learning Activities", by Loertscher & Minderhout

FHWA Course Design Process



Types of Learning Outcomes



Knowledge Tables

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 ways of being.

Freight Transportation Course

Course Design Document

Sample Learning Activity

Sample Facilitation Guide

Small Group Discussion

1. **What is the rationale for each section in the sample activity and its sequencing?**
2. **What course learning outcomes are supported by the sample activity? How are these aligned?**
3. **What knowledge table elements are woven into the sample activity? How is student proficiency with these elevated by tasks and questions?**
4. **In what ways do the materials (course design, sample activity, facilitation guide) address concerns of faculty teaching this course for the first time?**
5. **What lessons learned from examining these materials can add value to one or more of your courses?**

Large Group Reporting

Take turns sharing:

Answers to selected discussion questions

Insights about course and activity design

Burning questions about active learning

Project Title
Development, Deployment, and Assessment of a New Educational Paradigm for Transportation Professionals and University Students: A Collaboration of the Region X Transportation Consortium

Project Overview
The Region X Transportation Consortium is developing four course modules, delivering these modules in a unique distance-based learning environment, testing the efficacy of the modules in meeting program goals, and providing a means to disseminate materials and lessons learned to a national audience. The modules are learner-centered, built upon our extensive experience in creating active, problem-based learning environments for our transportation students, and validated by pedagogical research funded through the National Science Foundation and others. A substantial body of research demonstrates that problem-based environments produce students who perform better at solving novel problems and other positive learning outcomes.

Project Objectives
The objective of the Transportation Education Development Pilot Program (TEDPP) is to "develop, test, and revise new curricula and education programs to train individuals at all levels of the transportation workforce." We have targeted a diverse audience of university students and transportation professionals from the four states of the Region X Transportation Consortium who work in the area of transportation engineering and planning. Our goal is to attract new students to the field of transportation engineering and to train and retain practicing professionals by creating a learner-centered educational environment that addresses crucial issues in transportation engineering and planning. To meet this goal, we established the following objectives for our work:

1. Develop a set of four modules (defined below) and the relevant learning materials based on the principles of active, problem-based learning.
2. Develop distance-separated, interactive learning environments based on sound educational practices in which the modules can be deployed and tested.
3. Create teams of students and practitioners to pilot test materials.
4. Design and implement a detailed evaluation and improvement cycle for each module.
5. Assess the learning process and student outcomes.
6. Disseminate what we've learned in this project to a National audience.

Project Focus
"A fundamental difference between what we are proposing here and the more traditional university or professional development course is that courses will not be lecture-based. Rather, we are proposing an approach based on validated educational research that combines the methods known as active and problem-based learning. Too often, transportation courses focus on the use of a particular tool, such as traffic simulation or transportation planning models. Research has shown that reorienting a course to focus on a generative problem, then allowing the student instructor teams to develop the material needed to solve the problem, builds not only the technical skills required but also the communication and collaboration skills needed in today's work environment. A substantial body of research has shown that the outcomes from such learner-centered environments are more significant than those produced by more traditional educational approaches."

Project Outcomes

- Activity Books for each of the four course topics: freight, transportation data analysis methods, geometric design and safety, and traffic signal systems design.
- Facilitator Guides, providing instructors with information that they need to guide the activities.
- Course design documents, describing the process and outcomes of the course design process.
- Workshops to train educators and to disseminate course materials.
- Web site with all project materials and discussion threads.

Project Web Site
http://transportationeducation.wordpress.com/

Course Design Document

A course design document was developed that has evolved over the past four years as the curriculum materials have been designed and tested in five course instances. The course design document includes an audience analysis, a description of the course environment, the vision for the course, the learning outcomes, a knowledge table, the course assessment and evaluation system, unit planning, an activity design template, and the lesson plan (instructor guide) template.

This document is based on the curriculum design process developed by Apple, Beyerlein, and others [Pacific Crest Handbooks: Course design, Activity design]. The process was adopted for use in this project and is summarized in Figure 1,

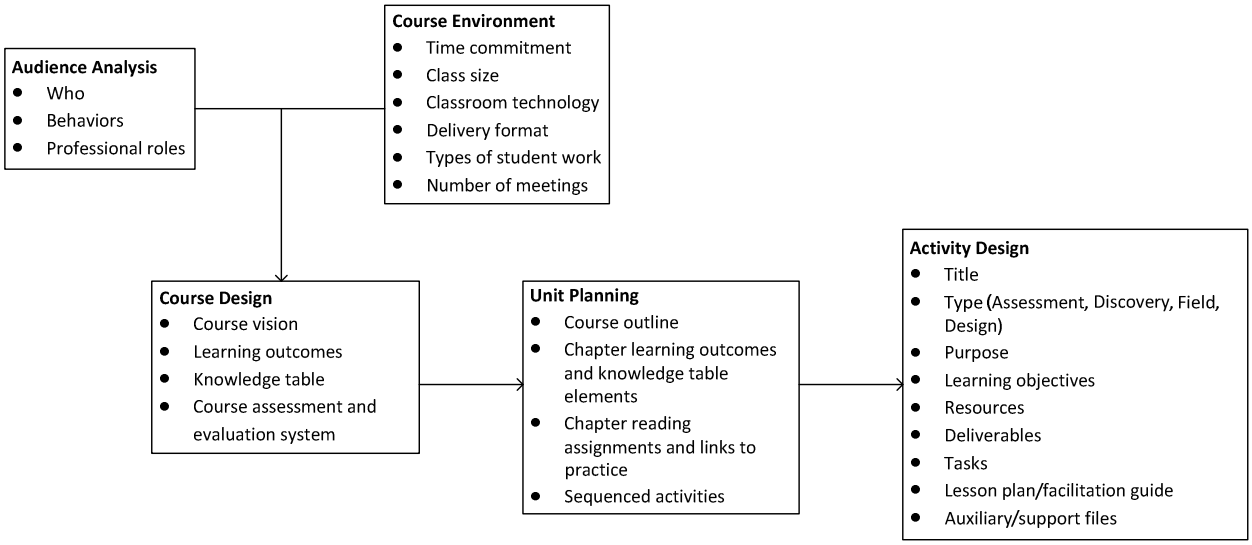


Figure 1. FHWA Course Design Process

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 they are, and what they know. This 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.

The physical and temporal features of the **course environment** need to be established before significant progress can be made in course design. This includes the location 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.

It is important to articulate an overall **course vision** 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.

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 10-12 course outcomes. 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.

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 **Error! Reference source not found.**). 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.

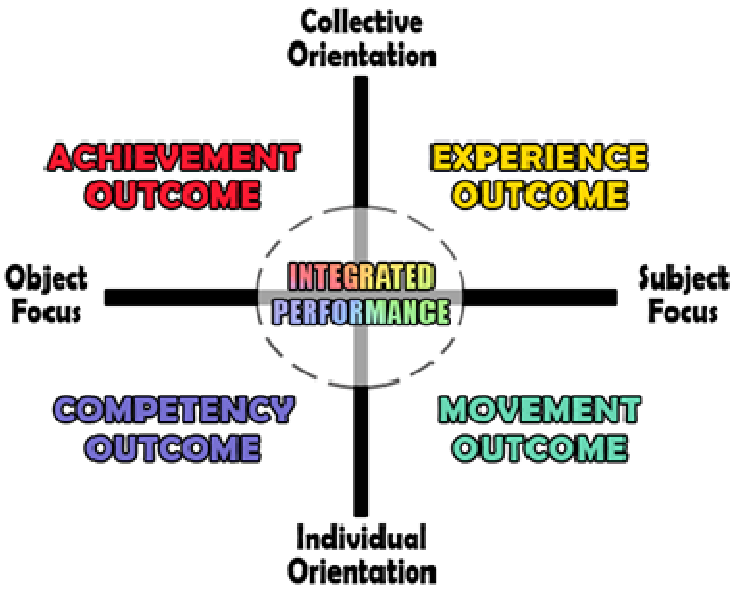


Figure 2. Types of Learning Outcomes

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 (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. ***Examples:***

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. ***Examples:***

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

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. ***Examples:***

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. ***Examples:***

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. ***Examples:***

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.

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.

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:

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

Course Design Document

Module Title: Freight Transportation

COURSE vision:

An exploration of freight transportation and introduction to applications of freight modeling which can serve to enrich the overall knowledge base of a transportation engineer, as well as provide a gateway for further study and research in the field of freight transportation.

ACTIVITIES:

Unit	Activity	Learning Objectives
Defining the Freight Systems	Mode Matrix	• To be able to define and describe components of the freight transportation system. • To be able to compare economic and operational characteristics of modes. • To do independent research and report findings to the class.
	Commodity Flow	• Understand how a given commodity moves through the freight transportation system. • Understand why certain commodities often travel via specific modes. • Identify these typical modes based on commodity characteristics. • Highlight features of the supply chain of a commodity which result in mode choice. • Relate concepts introduced in previous lectures and discussions to a specific commodity. • To do independent research and report findings to the class.
Contemporary Issues	Contemporary Issues	• To be able to describe common current issues regarding freight transportation. • To understand how freight and freight issues impact our society and communities.
	Innovations in Urban Freight	• To gain a better understanding of current urban freight issues and solutions.
Stakeholders & Incentives	Port of Seattle	• To become familiar with the Port of Seattle's governance and revenue structure. • To gain familiarity with transportation and activities performed by the port.
	Identifying Stakeholders	• To be able to list the stakeholders within a system.
	Beyond the Obvious	• To better understand the role of less visible freight organizations in the freight transportation system.
Performance Measures	-	-
Policy & Impacts on Systems Performance	Modal Conflict Project	• To identify, assess, and propose solutions for conflicts between freight and other modes of transportation (specifically bicycle and pedestrian) within the City of Seattle.
Aggregate Modeling	Freight Analysis Framework	• To become familiar with FAF, including its development, components, and uses. • To gain an understanding of the data that can be extracted by FAF3. • To use information from FAF3 to verify previously discussed concepts regarding freight movements. • To practice written communication skills.
Fleet Modeling	Fleet Modeling	• To understand the basic concept of vehicle routing and the VRP. • To be introduced to and use a modeling tool. • To identify tradeoffs between costs, emissions, and customer service within fleet routing.

Table 1: Learning Outcomes – Freight Transportation Module

1. Competencies	*2. Movement*	*3. Experience*	*4. Integrated performance*
1.1 Define and describe the freight transportation system: compare the economic and operational characteristics of modes, catalogue stakeholders and list their objectives, identify the logistical drivers of operations within the system. *1.2 Explain the effects of the constraints on transportation system efficiency and the significance of the policies that were used to regulate and deregulate the freight transportation system. Explain how policies impact the performance of the transportation system.* *1.3 Catalogue the critical freight issues which influence or are influenced by the transportation system.* *1.4 Identify the externalities of the freight system and the trade-offs associated with the mechanisms used to mitigate them.* *1.5 Define the structure of, data sources for, applications of, and limitations of a national freight modeling and fleet based modeling tools; and have competency using such models and interpreting results.* *1.6 Use quantitative data to measure truck or system performance activity; be able to compare and contrast performance measures and their limitations.*	*2.1 Value and appreciate the complexity of multi-disciplinary, multi-stakeholder problems with multiple objectives.* *2.2 Develop skills for responding to open-ended questions and for decision making under uncertainty.* *2.3 Develop critical reading and research skills, such as identifying key information, identifying author viewpoint, potential bias, method integrity, and likely impact on results and conclusions reported in technical literature.* *2.4 Improve oral and written communication skills, specifically related to communicating independently researched information to a larger audience.* *1.* *2.*	*3.1 Interact with the freight community to learn about current issues concerns, and applications.* *3.2 Gain familiarity with transportation facilities and their role in the transportation system.* *3.*	*4.1 Understand how and why freight is part of the transportation system and is related to the economy, environment, and society.* *4.2 Connect planning/decision problems with analysis methods and operations.*

Table 2: Knowledge Table– Freight Transportation Module

1. Concepts	*2. Processes*	*3. Tools*	*4. Contexts*	*5. Ways of being*
1.1 Systems description, operational roles, and incentives/motivations *- modes: rail, road, air, water pipeline;* *- infrastructure: highways, rail lines, ports, airports, intermodal facilities, warehouses;* - *stakeholders: shippers, carriers/3PLs, government agencies, communities* *1.2 Role of policy in transport systems performance* *- deregulation (various policies)* *4. - surface transportation (ISTEA, TEA-21, SAFETEA-LU)* *- City of Seattle Master plans (freight, bike, pedestrian)* *1.3 Contemporary freight issues: environmental, economic (including funding and carrier), and social* *1.4 Performance measures: travel time, travel time reliability, operation cost, emissions, safety, network resiliency* *- how to measure* *- how to use/apply* *- what is significance* *1.5 Aggregate modeling* *- structure* *- data sources* *- applications* *- limitations* *1.6 Fleet modeling* *- structure (VRP)* *- data sources* *- applications* *- limitations*	*2.1 Evaluating alternatives* *– identifying problem* *- identifying solutions (alternatives)* *- systematic evaluation* *– dissemination of results and conclusions* *2.2 Vehicle routing process (fleet management)* *- development of network and fleet parameters* *5. – use of objective function* *– interpret and synthesize results* *2.3 Critical reading methodology* *– recognizing validity and bias of source* *- identifying and synthesizing pertinent information*	*3.1 Excel* *- data analysis* *- fleet modeling (VRP)* *3.2 GPS data* *- data extraction* *- use of data to validate concepts* *- interpret and synthesize results* *3.3 Commodity Flow survey* *- use of data to validate concepts* *- interpret and synthesize results* *3.4 FAF3* *- data extraction* *- use of data to validate concepts* *- interpret and synthesize results* *6.* 7.	*4.1 Global trade and globalization* *4.2 Freight infrastructure* *4.3 National, regional and local freight flows* *4.4 Current state of planning and programming* *4.5 Systems performance* *4.6 Societal impacts*	*5.1 Analyst* *5.2 Critical thinker* *5.3 Strategic thinker*

ASSESSMENT

8 Graded homework assignments	70 pts
Quizzes (your best 5 of 7)	15 pts
Participation score (completion of ungraded assignments)	15 pts
Total Class	**100 pts**

5 POINT RUBRIC (AS APPROPRIATE FOR EACH ASSIGNMENT)

Score of 5: Excellent
- Shows a thorough understanding of the theme of the assignment
- Addresses all aspects of the task, and often goes beyond what is required in the assignment
- Shows an ability to analyze, evaluate, compare, and/or contrast issues and events
- Richly supports aspects of the task with relevant facts, examples, and details
- Spelling and grammar are accurate

Score of 4: Good
- Shows a good understanding of the theme of the assignment
- Addresses all aspects of the task
- Shows an ability to analyze, evaluate, compare, and/or contrast issues and events
- Includes relevant facts, examples, and details, but may not support all aspects of the task
- Spelling and grammar are mostly accurate

Score of 3: Satisfactory
- Presents a satisfactory understanding of the theme of the assignment
- Addresses most aspects of the task or addresses all aspects in a limited way
- Shows an ability to analyze or evaluate issues and events, but not in depth
- Uses some facts, examples, and details
- Spelling and grammar are somewhat accurate

Score of 2: Fair
- Presents a vague understanding of the theme of the assignment
- Addresses most aspects of the task in a limited way
- Develops a faulty analysis or evaluation of the theme
- Uses few facts, examples, and details; and includes information that contains inaccuracies
- Spelling and grammar are generally weak

Score of 1: Poor
- Shows limited understanding of the theme
- Attempts to complete the task, but addresses aspects in a limited way, or not at all
- Lacks an analysis or evaluation of the issues beyond stating vague and/or inaccurate facts
- Uses little or no accurate or relevant facts, details, or examples
- Spelling and grammar are weak

Activity 9: Fleet Modeling

Purpose

To be introduced to the Vehicle Routing Problem (VRP) and fleet modeling through the use of a previously developed model, which allows for exploration of the relationships between costs, emissions, and customer service.

Learning Objectives

To understand the basic concept of vehicle routing and the VRP.
To be introduced to and use a modeling tool.
To identify tradeoffs between costs, emissions, and customer service within fleet routing.

Required Resources

Fleet Model (excel file)
Tutorial

Tasks

Complete the tutorial.
Compare and discuss your answers to the questions within the tutorial with those students around you.

Deliverables

Turn in your completed tutorial at the end of class or by March 6th.

Background

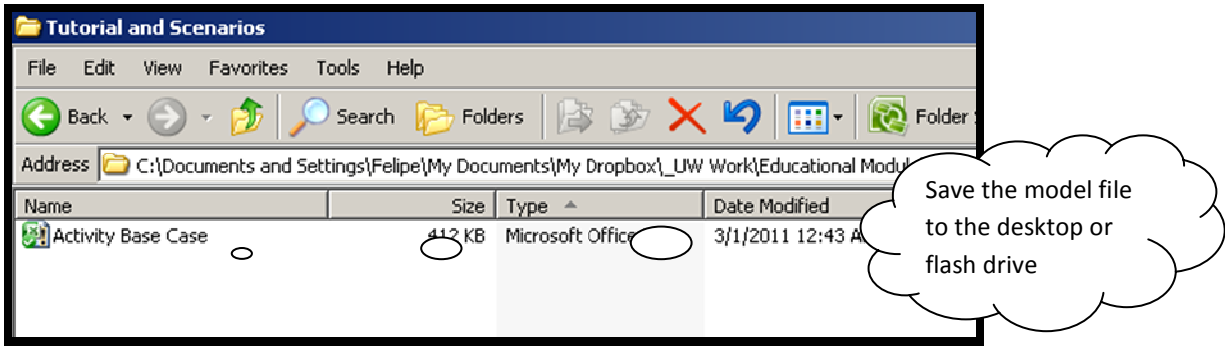
In the city of Seattle, a grocery delivery company receives grocery orders from their customers every day. The customers choose products and a delivery time window online. Based on this information, the company packs the orders in totes (plastic containers) and decides on the routing and thus the more precise time when each customer will be visited. Such routing and scheduling decisions are made by a vehicle routing model which minimizes cost based on information about Seattle's road network, fleet's characteristics, customer's location and demand.

In this activity, you are provided with a version of the vehicle routing model (a macro-enabled excel file) and will determine routing and scheduling for a particular fleet and customer demands. Using information about time windows, customer's demand, and fleet characteristics, you will calculate the routing and scheduling for a subset of this company's customers and observe how changes in inputs alter outcomes. The model is explained in more detail below.

1. Using the Model to Solve the BASE CASE

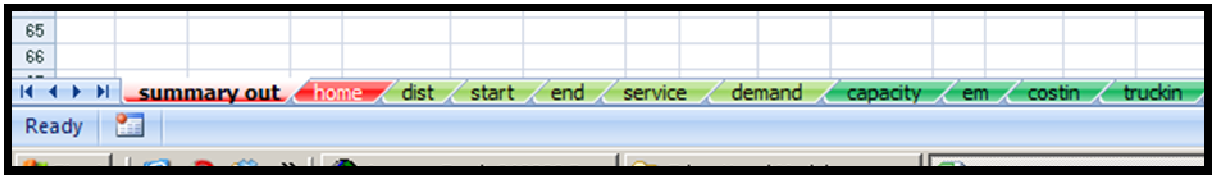
1.1. Open the model

Files needed for this activity are found on the class website. Save the file "Activity Base Case.xlsm" on either the desktop or a flash drive. Open the file.



1.2. Model Inputs

The BASE CASE inputs are already entered into the model. The input sheets within the model are labeled with green tabs. As seen below, light green tabs indicate inputs related to the network and customers, and dark green tabs indicate inputs related to the fleet. Ignore any other uncolored tabs as these sheets are only used for internal calculations.



In more detail, each of these sheets has the following information (information about each sheet can also be found by clicking the button located on the sheet) :

- **Dist**: OD matrix for all customer locations (57 total) and the central depot. The origins and destinations are noted in both row 60 and column BH. The values within the matrix are the distances (in miles) between any two locations. The "distance" between a customer and itself is a large number to discourage the model to visit the same customer on consecutive stops.
- **Start**: Beginning of the time window when a customer can be served (in minutes after midnight). The start time is in column A while the locations are noted in column B.
- **End:** End of the time window when a customer can be served (in minutes after midnight). The end time is in column A while the locations are noted in column B.
- **Service**: Service time required per customer (in minutes). The service time is in column A while the locations are noted in column B.
- **Demand**: The number of totes to be delivered to each customer. No goods are delivered to the depot. The demand is in column A while the locations are noted in column B.
- **Capacity**: The capacity (in totes) of each vehicle in the fleet. There are 5 vehicles in the fleet.
- **Em**: The emissions factors (in kg CO_2/mile) for each vehicle at 15 mph and 40 mph.
- **Costin**: The cost per mile and per minute for each of the vehicles in the fleet.
- **Truckin**: summary table of all inputs related to vehicles. The values in the worksheet are linked from the values in other input worksheets (**thus you will never need to make changes to this sheet**).

QUESTIONS 1.2

How far does a vehicle have to travel to get from customer 18 to customer 47? What about when the vehicle travels from customer 47 to customer 18? Why might these distances be different?

Between what times customer 10 can be served?

How much time is needed to deliver customer 14's totes?

What are the capacities of each individual vehicle in the fleet?

What are the emissions factors for the vehicles in the fleet?

Do the vehicles in the fleet produce more emissions when driving fast or slow?

Based on the capacities and emissions factors for the fleet, do you think this is a homogenous or heterogeneous fleet?

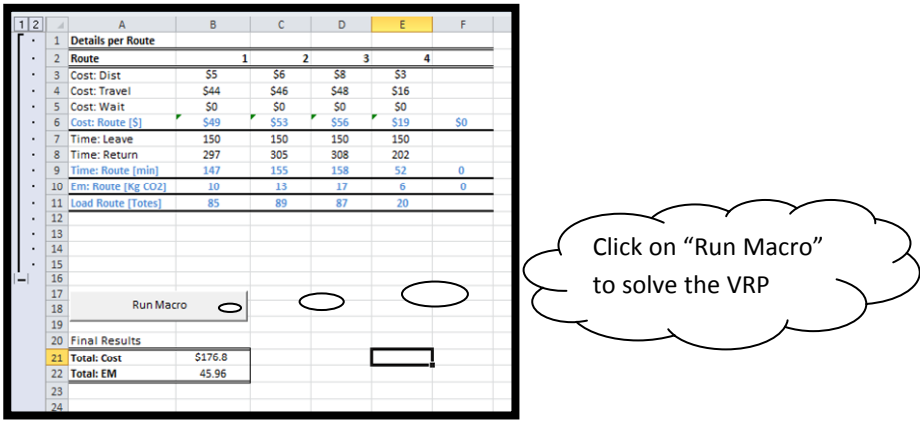
What is the total cost if TRUCK 1 drives 10 miles in 15 minutes?

1.3 Running the model

Return to the "home" sheet within the file.

Before you can run the model, you may need to enable macros. Click on the "options" button next to the Security Warning, just below the excel toolbars. In the pop up box, click to enable the macro.

To run the model once the macro has been enabled, click in the "Run Macro" button. The file will start flashing and values will begin populating the cells. Don't worry, this is normal!



2. Using the Model to examine a heterogeneous fleet

The base case uses a homogeneous fleet (vehicles with same capacity, cost per mile, cost per minute, and emissions per mile). Now we will look at a heterogeneous fleet to solve the same problem. To do this, you will need to update the fleet inputs in the Excel sheet.

Heterogeneous Fleet: Case 1

2.1. Rename and open the model

Open the original file (Activity Base Case.xlsm) and save it as "Heterogeneous Fleet Scenario 1.xlsm". Note that you must save the file as an "Excel Macro-Enabled Workbook (*.xlsm)" file.

2.2 Change fleet input data

Change the input values for the fleet using the information provided in the table below.

Truck	Capacity	Emissions @ 15mph	Emissions @ 40mph	Cost/mile	Cost/min
1	50	0.6	0.3	0.1	0.3
2	50	0.6	0.3	0.1	0.3
3	50	0.6	0.3	0.1	0.3
4	150	0.9	0.6	0.3	0.3
5	150	0.9	0.6	0.3	0.3

2.3 Running the model

Return to the "home" sheet and click on the "Run Macro" button to solve the new heterogeneous fleet problem

2.4 Understanding the output

As before, a summary of the routes can be found in the "home" sheet and detailed routings at a route-level are printed in the "summary out" sheet. Use this information to answer the following questions.

Activity has been abridged for workshop purposes. The questions below illustrate some of the additional material covered in the activity.

QUESTIONS 2.4

Are more or less trucks needed in this scenario when compared to the base case? Why?

Are the total emissions higher or lower than the base case emissions? Why?

Why do the costs per minute values not change?

QUESTIONS 2.9

Summarize the differences in the results using the two different heterogeneous fleet orderings. Compare number of vehicles used, emissions, and cost.

Are the above results what you would expect? Explain how the ordering of vehicles impacts overall cost and emissions.

Based on the results of each scenario, if a fleet manager wanted to minimize emissions, how would you tell him/her to order trucks? Does this order also minimize cost?

QUESTIONS 3.8

What is the trade-off in terms of cost and emissions between each of the scenarios modeled?

What is the trade-off in terms of customer service between each of the scenarios modeled?

FINAL COMPARISON

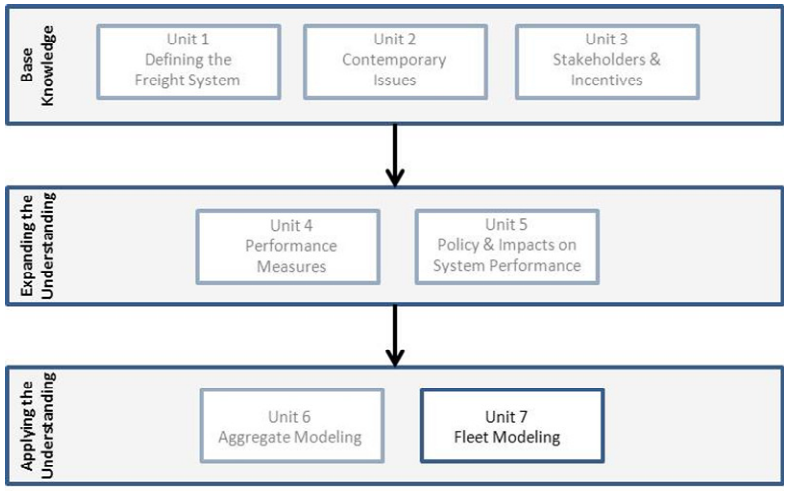
Using the data and results of this activity, make 3 conclusions regarding urban vehicle routing?

Activity #9: Fleet Modeling

Before Class
• Review the *Connection* to see this activity fits in as part of the course and Unit 7. • Read the *Essay* to learn more about the content of the activity. • Review the *Required Resources* to make sure that you have the materials that you need for this activity. • Read the *Script and Slides* to prepare for what you will do in class during the activity. • Review the *Pre-Class Preparation* for you and for students.

Connection

Activity #9 is the final assignment within Unit 9: Fleet Modeling which introduces students to the needs, motivations, and limitations within fleet modeling and to methods to solve vehicle routing problems.



In Activity #9, students are introduced to the Vehicle Routing Problem (VRP) and fleet modeling through the use of a previously developed model, which allows for exploration of the relationships between costs, emissions, and customer service.

Unit 7 Fleet Modeling
• Fleet Modeling Lecture • **Fleet Modeling In-class Activity/Assignment**

Essay

Activity #9 follows a lecture on the concepts and theory regarding fleet modeling, and consists of an in-class component. During the in-class activity students are asked to complete a tutorial which walks students through the use of a vehicle routing problem (VRP) based on grocery delivery in the Seattle area. In this activity, students are provided with a version of the vehicle routing model (a macro-enabled excel file) and will determine routing and scheduling for a particular fleet and customer demands. Using information about time windows, customers' demand, and fleet characteristics, students will calculate the routing and scheduling for a subset of this company's customers and observe how changes in inputs alter outcomes.

The learning objectives for Activity #9 include:

- To understand the basic concept of vehicle routing and the VRP.
- To be introduced to and use a modeling tool.
- To identify tradeoffs between costs, emissions, and customer service within fleet routing.

Required Resources

You will need the following material for this activity:

- Activity #9 text
- Excel files (Activity Base Case.xlsm and new_time_windows.xlsx)
- Computer lab (one computer per student)

Pre-Class Preparation

For the instructor:

- Review the *Connection*, the *Essay*, the *Required Resources*, the *Script,* and the *Solution and Notes*.

For the student:

- The pre-class component should be comfortable with the information presented in the Fleet Modeling lecture.

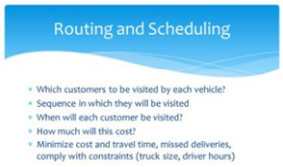
During Class
• Review the *Agenda* with the students to show them what tasks will be completed during class and the approximate time for each task. • Use the *Script* to remind you of the information that you need to remember and the sequence that you will follow during class. • Keep in mind the *Common Questions* that have been asked by students about this activity in the past. • Keep in mind the *Discussion Notes/Ideas* that you can use during class.

Agenda

- Activity #9 (approximately 80 minutes)
- The instructor is to facilitate the activity by answering questions regarding the tutorial.
- Students will work independently but are encouraged to consult with other students regarding concerns.
- During the session, the instructor should observe students, noting problems and addressing concerns.

Script and Slides (abridged for workshop purposes)

(Note – the slides presented in this section are part of the lecture given in the previous class meeting and are only included in this facilitation guide for workshop purposes.)

	• Background material for upcoming activity • Fleet – group of vehicles owned by a single carrier • Can vary in size from 1 vehicle to hundreds of vehicles • Service a set of customers • Objective – to service all customers in the most efficient way possible
	• Decision making required (to reach objective) • Strategic decisions are long term and require an investment; includes *(bullets)* • Operational decisions are short term, often made daily; includes *(bullets)* • Both these types of decisions can be informed by fleet modeling
	• Routing and scheduling is an operational decision • Includes *(bullets)* • Addressed by numerous operations research methods
	• One such method is the travelling salesman problem • Given a list of cities and their pairwise distances, the task is to find the shortest possible route that visits each city exactly once • Costs associated with travel along each link • In addition to serving each customer, the objective is also to do this as the lowest possible cost and/or in the shortest possible amount of time

Discussion Notes/Ideas

Additional questions which could be asked during the activity session:

- How can you determine vehicle utilization using the output data?
- Do cost and emissions increase or decrease when time windows are narrowed? widened?
- (prior to running the model) How do you expect cost and emissions, and emissions and customer service to be related?

- How many routes/vehicles are used to service all the customers?
- What is the total cost and total emissions produced to service all customers?
- What time does the second truck leave the depot and what time does the second truck return to the depot?
- Which route is the most expensive?
- Which route has the highest CO_2 emissions?
- What is the first customer visited in the third route?

After Class

- Use the *Solution and Notes* to help you evaluate the work of the students.
- Use the activity assessments to make adjusts to the activity if needed.
- Use the *Next Steps* to remind you of what comes next, including any homework or preparation that students need to do for the next class or activity.

Solution and Notes (for workshop purposes abridged solution is shown)

Tutorial Questions (with answers):

QUESTIONS 1.2

How far does a vehicle have to travel to get from customer 18 to customer 47? What about when the vehicle travels from customer 47 to customer 18? Why might these distances be different?

5.85 miles/5.40 miles
The distances may differ due to considerations such as one-way street and on/off-ramps.

Between what times customer 10 can be served?

2:30 am – 6 am (150-360 minutes after midnight)

How much time is needed to deliver customer 14's totes?

8.4 minutes

What are the capacities of each individual vehicle in the fleet?

90 totes

What are the emissions factors for the vehicles in the fleet?

0.7 kg/mi @ 15mph; 0.4 kg/mi @ 45mph

Do the vehicles in the fleet produce more emissions when driving fast or slow?

slow

Based on the capacities and emissions factors for the fleet, do you think this is a homogenous or heterogeneous fleet?

Homogenous – all trucks have the same capacities and emissions factors

What is the total cost if TRUCK 1 drives 10 miles in 15 minutes?

*10mi*0.2$/mi + 15min*0.3$/min = $6.50*

Next Steps

This activity is the last within the course module.