NORTHWESTERN UNIVERSITY Spring Quarter 2023
Transportation Systems Analysis and Planning Amanda Stathopoulos

CIV_ENV 377 Behavioral Choice Modeling in Engineering

Credits:	1
Room:	Technological Institute LG68
Time:	M+W 10:00–11:50
Instructor's Office:	Tech, Room A312
TA/Grader:	TBA
Office Hours:	W 12:30 – 1:15 or by appointment, see canvas for slots
E-mail:	a-stathopoulos@northwestern.edu

Behavioral choice modeling provides a scientifically robust method to investigate and understand how choices are made in a variety of systems and contexts. In this course you will learn methods to conceptualize, design, implement and finds practical answers to choice modeling problems in a variety of settings, including transportation, energy, water, consumer science, health, food preferences, residential location and more. This course builds on a previously taught 400-level class which has been adjusted to reach a broader audience in 2022. In this new course students will learn behavioral theories and methods to study human decision-making in engineered and natural systems, how to estimate demand for innovative products and services, and how to quantify non-tangible effects. CEE-377 will equip students with tools to study the complexity of human decision-making processes that are influential in all disciplines of engineering and beyond. The course is designed to learn by doing creative and open-ended work, and students will get a chance to design their own study, collect data, and analyze findings.

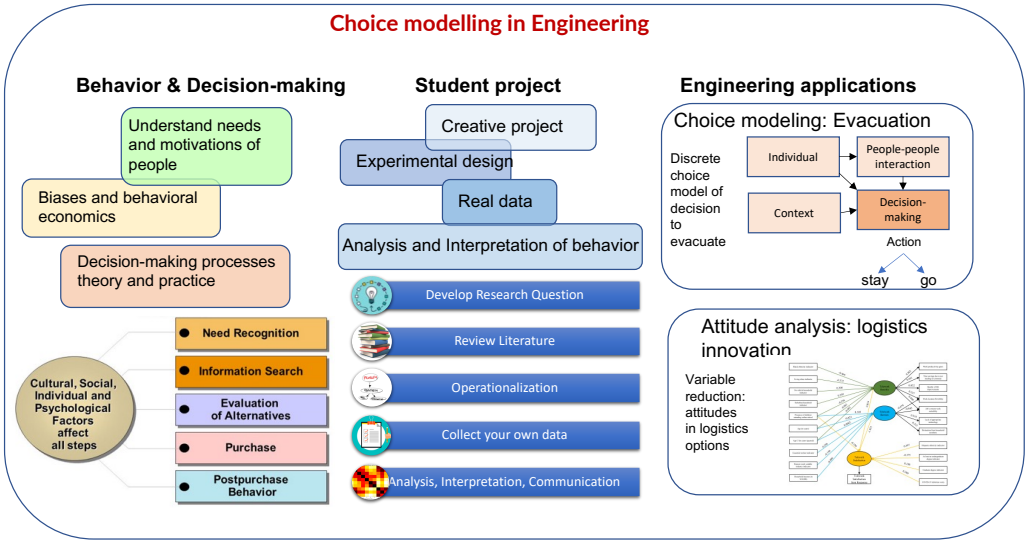
Who should take the class?

The audience for this course is upper-division undergraduate (Junior/Senior), students in the Transportation & Logistics Minor, and graduate students in Engineering and Sciences. For undergraduate students, the course counts as 100% engineering content and is suitable as a technical elective. The quarter long 'mini research project' is suitable for master student or PhD student graduate research experience, or as a final MS paper.

Prerequisites

Students need to have taken a statistics or probability class such as CIV-ENV306 (or equivalent). We will do lab activities using R, you do not need to have choice modeling programming knowledge, but I will expect knowledge of statistical theory in lectures and labs. If you have questions about prerequisites email the instructor.

Figure 1: Course outline



Course Description

In this course students will learn both theory and practice of behavioral choice modeling. The course is centered around a quarter long behavioral research project where students learn about all the stages of independent research, covering the main stages of research, from formulating a research question, to experimental design, data-acquisition and analysis.

The course also covers the theory and practice of choice modeling, behavioral analysis, and latent variable analysis, using psychological constructs and factor analysis to better understand decision making processes that play an important role in engineering system impacts. To support application and 'learning by doing', the course will use R software and hands-on sessions to teach data-exploration, experimental design, logit modeling, and Exploratory/Confirmatory Factor analysis. The knowledge gained from this course is valuable for research and professional practice in planning, operations and management of engineered systems affected by human preferences, goals, attitudes and biases.

Course Objectives

1. Develop knowledge of the role of behavior and decision-making in students own disciplines
2. Foster creativity and autonomy in students by designing your own research project
3. Demonstrate understanding of the main theories and concepts in choice modeling (e.g. utility theory, behavioral economics, decision-making, attitudes, biases)
4. Develop hands-on skills in the main stages of behavioral research covering research question design, literature, experimental design, data-collection and modeling)

5. Develop skills in handling decision-making data and using relevant software to estimate and interpret simple choice models
6. Develop skills in using relevant methods to design and analyze attitudinal (latent variable) data
7. Demonstrate skills in effective audience-specific written, graphic/visual, oral and interpersonal communication related to choice models and research
8. Show critical thinking skills. In this course this is centered on: a) consideration of different theories, perspectives, explanations; b) ability to incorporate both qualitative and quantitative aspects in your project.

Course Format

This course is based on inquiry-based learning. Classes are combination of lectures, discussions, hands-on activities, and computer lab work. Students are expected to read assigned texts before class and to participate in class discussions and activities. Homework assignments will be given and analysis of these assignments will be the basis for some class discussion during the class immediately following their due date, so it is essential to complete assignments **on time**.

Course Schedule

Class will meet in LG68 in TECH on Mon & Wed[1].

Course topic outline, preparation, and summary of deliverables

There is no specific textbook in this class, but resources will come from articles, videos, podcasts, and other material posted on Canvas. Assigned readings for particular classes will be announced in advance, either in class or in the announcements section on Canvas. Students should check the Canvas 'study-guide' regularly for updates. Figure 2 shows the week-by-week plan for topics, class activities and deliverables.

Evaluation

Given the focus on inquiry-based learning, the main independent activity of class participants is to design, implement and analyze a behavioral study. The grade is based on three main activities, namely participation throughout the quarter, two modeling home-works, and a larger class-long project. There will be no other final exam beyond the components listed. Table 1 gives a summary of activities in the class.

For attendance, please inform me ahead of time about any absence. For a missed class you need to provide a 1-page summary of main reading/resource and send that in by email with

[1] There will be no class on Memorial day May 29th

Figure 2: CEE377 schedule

Week 1	Course Introduction		Due
	Monday Mar: No class	Wed. March 30: Overview of behavioral research: why do we need behavioral studies? Promise and peril. Dissecting notable behaviroal constructs. 5 steps of inquiry-based research. Overview of class, enquiry-based class projet; assessment and project; Introductions	HW: Download and install R project (solo).
Week 2	Experimental psychology & Social Psychology: Focus on Happiness research and research methods		Homework (HW)/Assignments (A)
	Monday: Developing a research question; Methods for creativity; Summary of research with behavioral constructs; Reading and discussion of paper on creativity in science.	Wednesday: Literature search methods; Introduction to types of data in behavioral studies (stated versus revealed); Reading and discussion of experimental psychology paper: cover take-home discussion questions	HW: Paper reading and reflection (participation). | **A: Deliver initial ideas for project and resources for feedback** (ungraded)
Week 3	Behavioral Economics; Focus on policy and research by John List		HW/Assignments
	Monday: The behavioral economics approach to research, methods, data. Summay of rational and non-rational choices. Reading of Behavioral Economics paper and class experiments.	Wednesday: John List freakonomics podcast discussion; How does experiments translate to policy and practice? Reproducibility and scaling; Discuss class project, primer on ethics, data, design, administration.	HW: Podcast/Paper reading. | **A: First research study report due** (graded)
Week 4	Choice modelling: utility-based decision analysis; Focus on evacuation modeling (theory and design)		HW/Assignments
	Monday: Theory of random utility modeling; specifying a choice model; hypothesis testing; estimation and interpretation (generic/specific effects, main and interaction effects, attribute and person-factors). Exploratory Data Analysis, summary statistics; Guidelines for 'reading a model output': class activity	Wednesday: Stated versus revealed data revisited. Developing an experimental design; design theory; full factorial and fractional factorial design; blocking; Case study of Qualitative design for evacuation model with social influence; Hands on/discussion.	HW: deliver a plan for meeting and work in 'modeling team' Deliver initial ideas for project and resources for feedback. || read Evacuation Model Handout || HW: ideas for design
Week 5	Choice modelling (part 2): Focus on evacuation modeling (application)		HW/Assignments
	Monday: Recap of exploratory data-analysis and estimating a simple choice model. Computer R studio Lab walk-through; Independent work on estimation of a first model in small teams.	Wednesday: Computer Lab: More advanced models; socio-demographics; interactions and random parameters; testing and comparing models. Independent work on advacned specifications	HW: Read case study & modelling guide || **A: Deliver draft lab report**
Week 6	Mixed methods research: qualitative and quantitative. Focus: TBD		HW/Assignments
	Monday: Designing a research instrument; question wording; Pitfalls and best practice; Sensitivity and threat; Qualitative and quantitative data collection; New forms of data	Wednesday: Advanced experimental design methods; realism and respondent behavior; Efficient design theory || Independent work on project. Q&A on Choice Model results and interpretation	**A: Deliver lab report on choice model results** (estimation, interpretation) ||HW: reading on question design
Week 7	Attitude Modeling: theory. Focus on delivery automation acceptance		HW/Assignments
	Monday: Theorizing and measuring unobservable variables; The essential steps to theorize and model latent variables. Walking through a case-study	Wednesday: Modeling constructs -- Dimensionality reduction. Principal component analysis (PCA) theory. Class discussion of food-preference case-study. Peer feedback session (1 hour)	**A: Deliver a draft for research study design** || HW: reading on Latent variables & PCA models
Week 8	Attitude Modeling (part 2): theory. Focus on delivery automation acceptance		HW/Assignments
	Monday: Recap pf latent variable dimensionality reduction. Case study introduction: acceptance of delivery automation. Computer lab: walking through PCA modeling --> 4 rules of model selection. Independent work	Wednesday: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Computer lab on EFA model selection and rules. Independent work	**A: Deliver final research study report** || HW: Read case study & modelling guide
Week 9	Current debates in choice modeling		HW/Assignments
	Monday: web-based studies and devices; behavior studies in the big data era; Paper discussion. Theory and practice of Structural Equation Modeling	Wednesday: Q&A on PCA/EFA model results and interpretation. Summary of class activities. Discussion and take-aways: Small vs. large data. Passive and natural experiment approaches. Choice vs context. Observable vs. Unobservable. Declared vs. Inferred behavior.	**A: Lab report on PCA/EFA model due** || HW: reading on quantified traveller
Week 10	Class presentations; discussing lessons learned		HW/Assignments
	Monday: Memorial Day (no classes)	Wednesday: Class presentations	A: Presentation of
Exam week			HW/Assignments

Table 1: Class evaluation plan

	Percent of grade	Description
Participation (class attendance + weekly homeworks + active participation)	10%	The class participation part of the grade covers attendance in class, and homework completion. Both of these are needed for active participation, which is expected in this class. Active participation is reflected through insightful questions, labs, and discussion in class.
Modeling projects with Lab report assignments	30%	Two modellign class homeworks will be used to understand theory, and practice coding, running, interpreting and analyzing of models. In 2022 we will have an evacuation choice model [15%] and delivery innovation attitudinal model [15%] due in the form of lab reports.
Mini research project with research report assignments	60%	Students will design an independent creative mini research project that runs through the entire course with 4 main deliverables: i) Define research question with literature support [report 10% grade] ii) design and implement a study (e.g. survey, behavioral test, natural experiment, etc) including design of questions, measurements, sampling, controls [report 20% grade]; iii) carry out qualitative or statistical analysis to respond to the research question. Results will be presented orally to class [10% grade] as a proposal presentation, and all stages of the project will be assembled and summarized in a mini-paper [20%]

header 'CEE377 missed class makeup'. More than 2 missed classes requires that you contact me to discuss further, so that I can make sure you stay on track.

The class modelling projects are designed to learn the theory and practice of discrete choice modeling and attitude analysis and students will be assigned a dataset to work on for empirical modelling. A short report with the model results and interpretation will be handed in. Students may work in teams but each student will hand in their own report.

For the quarter-long research project students will propose their own investigation, and work on design, data-collection and analysis, with 4 main deliverables that reflect the different stages of maturation of the project. Each time, a week prior to report due-dates there is a check-in with the instructor for feedback and clarifications.

Deliverables and grading

There are two main types of deliverables in this class, homeworks and assignments. On most weeks there will be homeworks (HW) due, such as readings, quick-writes, or brief reflection activities. These activities are part of the participation grade and are essential to the class activities. Assignments (A) take the shape of reports and will be delivered in Canvas,

Figure 3: Grading scheme (% to letter grades)

Grading Scale (% to letter grades)		
Percentage	Letter grades	Expected Performance
93 -100	A	Excellent
90 -92.9	A-	Very Good, very minor mistakes
86 -89.9	B+	Good
83 -85.9	B	Solid but some room for improvement
80 -82.9	B-	Consistent Issues
76 -79.9	C+	
73 -75.9	C	Significant weakness
70 -72.9	C-	
66 -69.9	D+	
63 -65.9	D	Passing but many failed elements/tasks
60 -62.9	D-	
0 -59.9	F	

preferable in pdf or doc(x) format. Keep in mind that given the focus on an independent project in the class, high quality and thoughtful work is expected; leaving assignments to the last few hours before the deadline will likely not yield good results. Grading is based on Letter grades. The grading translation scheme is shown in Figure 3. A student can petition for P/N grading, whereas the cutoff will be at B+ (86%).

Late policy and Grace days

- The cutoff for assignments is posted on Canvas (typically at midnight on the due date).
- Any late submissions of assignments will be assigned a penalty of 10% of the grade per day late. Assignments will not be accepted and graded past 3 days late.
- You are granted two 'no explanation needed' grace days for assignments. This means you can give yourself an extra day without penalty for graded assignments. I recognize that even careful plans can sometimes be derailed by illness, computer problems, theft, or personal situations. Students get to decide if and when to use the grace days, and you do not need to explain or notify me. This gives you the power to decide how to dispose of the grace days.
- Any grace days that remain at the end of the course will be used as a grade bonus.
- Instructor granted extensions will only be considered after the grace days are used. Any extension beyond the grace day(s) are only for exceptional circumstances and need to be discussed and granted before the assignment is due.

- Grace days only apply for 'Assignments' not for 'Homework' because the latter are needed for students to be prepared for class activities.

Office Hours

Office hours are held in tech A312. Questions are likely to arise in relation to independent work, and not on a regular schedule. As such, it is usually quickest to communicate questions and resolve issues via e-mail or ask for an appointment via mail a-stathopoulos@northwestern.edu E-mail responses can be expected within 24 hours.