# Simulation Modeling Project
## in
## Advanced Mathematical Modeling Course

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# Metro State's Advanced Math Modeling Course
the course …

First offering in fall 2019; second offering in spring 2021; meets once a week

Exposure to large open-ended problems → course is project-based

Significant emphasis on technical communication:

problem solving in teams

writing technical reports

writing executive summaries (*New Spring 2021*)

presentations

# Metro State's Advanced Math Modeling Course
the students...

Industrial & Applied Math Majors

Adult learners preparing for careers as analysts around the Twin Cities

Prior applied math coursework includes:

> introductory mathematical modeling (Excel)
> differential equations
> statistics (R, JMP, Minitab, SPSS)
> optimization (LINGO, Excel)
> stochastic processes
> numerical analysis (VBA)
> additional programming (Python, JAVA)

# Project Idea (fall 2019)

## Swede Hollow Café

- 2 blocks from Metro State

- coffee destination for math & science faculty

- first floor of café can get congested at lunch time

Investigate experience of grab-n-go customers coming in for coffee or specialty drink around lunchtime.

# Data Collection (fall 2019)

Not possible for students to collect data:

Metro State students generally have daytime jobs

3-4 week project duration

Data collected in advance by RW:

received okay from café owner

3 week days from 11:30 am until about 1 pm within a single week

additional info provided by café owner

# Data Collection (fall 2019)

Data collected; recorded in Excel:

arrival times of parties (days 1-2, $n \approx 50$)

sizes of parties (days 1-2)

barista drink preparation durations (day 3, $n \approx 50$)

Additional data obtained from SH owner:

approximate distribution of order types

typical cashier service durations → randomly generate service durations in Excel

# Math 430 Project 1 (fall 2019)
## the open-ended problem…

A café in Saint Paul serves a variety of foods, bakery goods, coffee, and specialty drinks like expresso, latte, mocha, chai, and hot chocolate. Lunch time is frequently a busy time of the day at the café. Some customers come for lunch while others who work in the neighborhood stop by to grab a drink during their lunch break.

The problem investigated here focuses on the experience of this later group of customers—namely individuals that come to the café, typically by themselves, and place drink-only orders. These individuals are frequently time constrained as they are picking up a drink and heading back to work. As these tend to be daily customers, it is advantageous for the café owners to understand the experience of these customers during the lunch time rush.

# Math 430 Project 1 (fall 2019)

**Project details:**

teams consisting of 3-4 students
provided data in Excel workbook and additional info
4-week completion time
"use what you've learned"

**Objectives:**

identify desired model outputs
make decisions about modeling approaches
recognize assumptions
make decisions about computational tools
develop project management and communication skills

# Math 430 Project 1 (fall 2019)
## the student experience…

Teams made similar decisions:

chose output variables: wait times and queue lengths

developed stochastic models

determined probability models for input variables

employed Monte Carlo simulation

used Excel; Python; various statistical applications for hypothesis testing

Intense experience

Communication and coordination was challenging

# Math 430 Project 1 (fall 2019)
## the student experience…

"I liked the open ended modeling assignments because it gives a glimpse into the real world where things are not always black and white. Instead, you are given information and have to pick and choose the best way to go about using it to accomplish goals."

"Like/dislike that it got me out of comfort zone. I learned a lot, as a result."

"Being able to solve and create models in a group was a great experience."

"This course pushed comfort levels for working in groups and really encouraged free thinking."

# Math 430 Project 2 (spring 2021)
the modified café queues project…

Expanded project duration:

6 weeks for problem solving; 4 weeks for communication of findings

increased expectations and added more structure

Significant expansion of the data set:

RW randomly generated data based on Swede Hollow Café data

3-day data sets provide time stamps for all front-end activities

included parties that balk

Student experience:

?

# Math 430 Project 2 (spring 2021)

## the modified café queues project…

**Objective 1:** Undertake a quantitative analysis of the actual observed front-end operations, utilizing the data provided, and summarize your findings. Identify any significant "hold ups" in the front-end system resulting in longer queues and wait times. Propose solutions.

**Objective 2:** Develop a model, consistent with your findings from Objective 1, to investigate and predict queue lengths and wait times. Some of your findings from Objective 1 should be integrated into your model. For example, customer ordering preferences should be integrated into your model because ordering preferences impact queue lengths and wait times. Other findings from Objective 1 should be used to investigate the *validity* of your model. *Validity* refers to how well your model agrees with actual observed system data.

**Objective 3** (Optional—time permitting):  Modify your model from Objective 2 to investigate one or more solutions you proposed in Objective 1. Investigate the impact of your proposed solution on the efficiency of the front-end system.

# Thank you!

# Questions?

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