Assessment of the impact of course scheduling in enrolment decisions with historical data

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Outline

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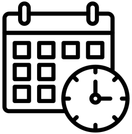
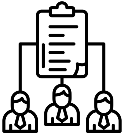
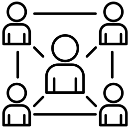
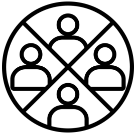
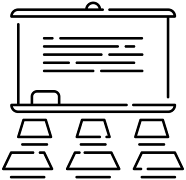
University course timetabling problem

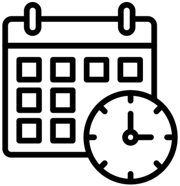
- **Allocation** of events (courses, lecturers and students) to a number of fixed resources (time slots and rooms).
- Five subproblems (Carter and Laporte, 1998):
  - Course timetabling
  - Teacher assignment
  - Class-teacher assignment
  - Student scheduling
  - Classroom assignment

Classroom assignment



- **Goal**: propose a tool to *LocauxMis* (Unifr) to **simplify** and make **more efficient** the **classroom assignment problem**.
    - Automatic generation of a **first assignment** of classrooms to courses by solving a mixed-integer linear programming (MILP) formulation using a commercial solver (Gurobi).
    - Manual adjustments to come up with the **final assignment**.
- **Data**: 1116 courses (weekly courses and *block* courses) and 76 classrooms.

Course timetabling



- **Focus**: curriculum-based course timetabling (CBCTT) problem.
  - **Conflicts** between courses set by students' curriculum.
  - **Teachers**' preferences and availabilities are taken into account.
  - **Students**' preferences are usually overlooked and assumptions are made by the analyst (e.g., compact schedules).
- **Goal**: embed a detailed representation of students' preferences into the CBCTT problem to **explicitly recognize** the **interactions** between such **preferences** and **timetabling decisions**.

Outline

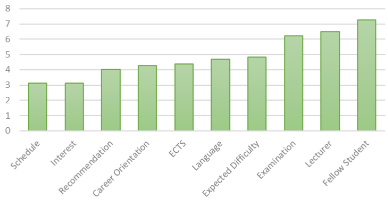
Factors influencing enrollment decisions

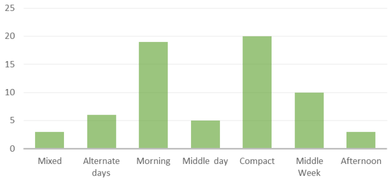
- Informal **discussion** during class to identify **relevant factors**.

Questionnaires

- Based on the relevant factors, we generated a couple of **short questionnaires** (<10 min) to assess the impact of the timetable on **enrollment decisions**.
- For the moment, only access to students in our courses: **not representative**!
- **First questionnaire**: rank of factors and predefined timetables (68 respondents).
- **Second questionnaire**: socio-economic characteristics, behavioral statements and ideal timetable (49 respondents).

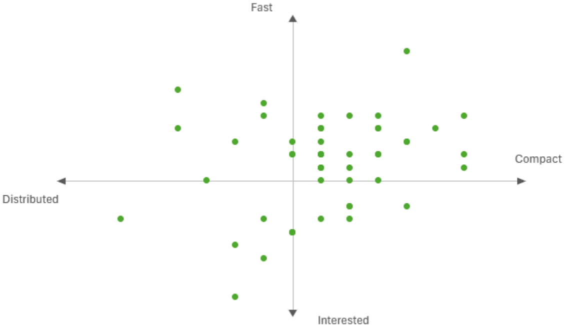
First questionnaire





- Students were asked to rank 10 influencing factors and 7 predefined schedules.

Second questionnaire (1)



- 10 **attitudinal statements** (on a 1-5 Likert scale) on the **nature of the timetable** (compact or distributed) and the **study intention** (fast track to get a diploma or interested driven).
- Tendency to privilege **compact timetables** and **fast track** (no relevant differences were observed among the considered segments).

Second questionnaire (2)

	Monday	Tuesday	Wednesday	Thursday	Friday
Early Morning	5	11	9	8	5
Late Morning	12	14	13	12	7
LUNCH					
Early afternoon	9	9	9	11	2
Late afternoon	2	3	5	3	1

	Monday	Tuesday	Wednesday	Thursday	Friday
Early Morning	18	28	28	25	14
Late Morning	23	28	31	29	13
LUNCH					
Early afternoon	18	21	15	13	6
Late afternoon	8	11	9	1	1

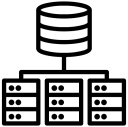
- Students were asked to allocate 10 slots in a timetable of 20 slots to generate their **ideal timetable**.
- **Segmentation**: long commuters (top) and short commuters (bottom).
- **Early morning** is less preferred by long commuters and **compact timetable** (Tuesday-Thursday) in general.

Outline

Context

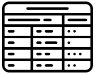
- Faculty of Management, Economics and Social Sciences.
- 4 main **bachelor study plans** and various **master study plans**.
- 35 **professors** and 120 **PhD students** and **senior researchers**.
- 1450 **students**:
  - 24% from Canton Fribourg, 56% from outside the Canton and 20% international students.

Available data



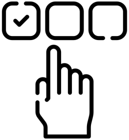
- **Time horizon**: from autumn semester 2014 to spring semester 2023.
- **Program data**:
  - Study plan, version, and language.
  - **Example**: Bachelor of Management, version 4, French.
- **Enrollment data**: students registered to one of the bachelor or master programs of the faculty. For each **student**:
  - ID, enrollment year, program, language.
  - ID of the enrolled courses each semester.
  - No socio-economic data due to privacy reasons.
- **Course data**:
  - ID, name, program, nature (weekly or block), language, teacher, ECTS.
  - Semester, timetable, classroom.

Data processing



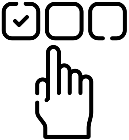
- **Time horizon**: from autumn semester 2018 to spring semester 2023
  - To avoid inconsistent data and to have full access to program data.
  - New students only in 2018 and in subsequent years we keep track of already enrolled students and new ones.
- **Program**: only bachelor students for the moment (139-491 students per semester).
- **Individual choice set**:
  - For each **student** at each semester being registered, we want to determine the courses they could choose from.
- **Enrollment data**:
  - **Choices** (enrolled courses) made by each student at each semester.
  - **Directly accessible** in the available data.

Individual choice set (1)



- We construct **universal choice sets** for each study plan + version + language (p), academic semester and year of studies (t) and natural semester (s): $\mathscr{C}_{pts}$. **Examples**:
  - $t = 1$ is the autumn semester of the 1st year of studies, $t = 4$ is the spring semester of the 2nd year of studies.
  - $s = 1$ corresponds to the autumn semester of 2018, $s = 4$ corresponds to the spring semester of 2020.
- The idea is that the **individual choice set** of student n in natural semester s, $\mathscr{C}_{ns}$, is a subset of $\mathscr{C}_{pts}$.

Individual choice set (2)



- However, due to individual situations (e.g., repetition of a course, exchange semester, internship), this **might not be the case**!
- Hence, to **construct** the **individual choice set** $\mathscr{C}_{ns}$:
  1. Add courses from the universal choice set: $\mathscr{C}_{ns} = \mathscr{C}_{pys}$.
  2. Remove courses previously chosen: $\mathscr{C}_{ns} = \mathscr{C}_{ns} \setminus \bigcup_{r=1}^{s-1} \mathscr{C}_{nr}$.
  3. Add chosen courses in s (W_{ns}): $\mathscr{C}_{ns} = \mathscr{C}_{ns} \cup W_{ns}$.

Outline

Data analysis

- Once $\mathscr{C}_{ns}$ and W_{ns} are fully characterized, we can generate the **attendance rate** to each course and semester (i.e., registered students/potential students).
- We will then identify **relevant changes** in the attendance rate to try to find the underlying reason(s):
    - **Internal** reasons: changes in the course's features (e.g., timetable, teacher, language).
    - **External** reasons: changes in other courses' features, changes in the course catalog, trends.

Research directions

- If the impact is relevant, the characterization of the **student preference representation** is envisioned:
  - Conduct a **survey** to gather socio-economic and preference data at the faculty level.
  - Develop a **preference representation** to embed it in the optimization problem formulating timetable decisions.

Multiple choice

- Each semester, a student can choose **multiple courses**.
- In a **discrete choice model** (DCM) **situation**:
  - Set of **mutually exclusive** and **collectively exhaustive** alternatives.
  - How can we define the **alternatives** here such that **only one** is **chosen**? (e.g., enumeration of potential schedules)
- There exists an **ECTS budget** to be allocated to courses: this choice situation can be seen as a **multiple-discrete continuous** (MDC) **situation**: $\sum_c p_{ns}^c x_{ns}^c = B_{ns}$.
  - **Budget** B_{ns} for each student n and semester s (which is constrained by University regulations and determined by the student).
  - Each **course** c has a **fixed *price*** p_{ns}^c (amount of ECTS).
  - The **consumption quantity** x_{ns}^c is a binary variable in this case (either the course is chosen or not).

Any question? Any suggestion?

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References and sources

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Michael W Carter and Gilbert Laporte. Recent developments in practical course timetabling. In *Practice and Theory of Automated Timetabling II: Second International Conference, PATAT'97 Toronto, Canada, August 20–22, 1997 Selected Papers 2*, pages 3–19. Springer, 1998.

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