# Market design project

## Problematic

The way the rooms are organized leads to inefficiencies, between professors who value and need different things. Some professors need to use boards to write specific, while others do not value such things. Moreover, the impact of the geographical positioning of the rooms relative to both the students and the teachers is something to take into consideration, or the proximity of the coffee machine, even the amount of stairs required to reach the room.

As such it is my belief that a new system designed around the principles of market design could lead to a more efficient allocation of the school’s resources, as well as collect valuable information term on term on what professors value and what type of classrooms they preconize.

## Due Diligence

### Current system at X

The current system at X is centralized, where the coordinators at the Registrar’s office are in charge of the allocation of rooms for their respective programs.

The school has a list of all the rooms and their capacities, available on a shared spreadsheet where the coordinators manually allocate the classroom according to availability and capacity. In the words of the Registrar’s office, the system works in the sense that all of the teachers have a room in which to teach.

However, it is time consuming for the Registrar’s office, there are times were bargaining has to take place between the different actors, and as said before, teacher can be unhappy with the allocation that they received as the classroom doesn’t fit their needs.

In my opinion, the system only works currently because the average size of a class is much different between the different formations and years present on campus. As an example, the “Cycle Ingénieur” (CI) average class size varies wildly as students increasingly specialize as they complete an extra year. During the Tronc Commun, were all students take the same classes (more or less) finding a room fitting over 550 theoretical students is a no brainer, simply allocate Poincare for the lecture, while the second year are in the different smaller rooms for their tutorials and the third years are not on campus. At the beginning of the year, the situation is harder with the large amount of third year programs, and the second year being at an intermediate spread level at around 120 students per program. In that case, choice need to be made between the third years and the needs of the second year classes.

At the same time, the Registrar’s office has now evolve and take into consideration the masters and bachelors that need rooms as well, and as the class size increases and the number of programs may increase, this equilibrium might fail at once point.

### Flaws

In terms of market design, this system is a centralized dictatorship, as in a control economy where resources are allocated based on the sole criteria of class size. It’s flaws which we will detail in the following table:

|  |  |  |
| --- | --- | --- |
| Flaw | Description | Intensity |
| Information Problem | * No preference elicitation * Manual spreadsheet means no way to communicate preferences, constraints, or trade |  |
| Matching Mechanism | * Single-Criterion Optimization : capacity matching * Manual Coordination Cost : bargaining * No formal Trading Mechanism : no beneficial trades |  |
| Incentive Problems | * No strategic reporting : no formal way to express the preferences for rooms or features * Lack of Price Mechanism : no way of quantifying preferences |  |
| Scalability | * Brittle equilibrium : program change or growth could pose a threat to the current system * Manual processing bottleneck |  |
| Efficiency problem | * No Optimization Algorithm * Suboptimal Outcomes : room for Pareto improvements * Resource Utilization : inefficient use of features and capabilities |  |
| Adaptation and flexibility | * Rigid system: changes mid-term can be difficult * Limited feedback loop: for allocation and features |  |

As we can see, while the current system has major flaws like the lack of a matching mechanism, it still ensures all teachers have a room, and the school has functioned with this system for the past few years without any issues.

## Proposed Matching System – Core System

This Algorithm follows the guidelines of a DA algorithm, professors and teaching assistants (here after “teachers”) submit their preferences, and the Classrooms have preferences based on the cohort size, and other factors the Registrar’s office finds important (for example, a reparation boosting the attractivity of teachers who were worst off last term/year).

* Teachers report their preferences over the different types of rooms available on campus, which can be based on multiple factors as explored earlier
* When the final cohort size are determined (one or two weeks before the start of the term), the algorithm is ran following the Deference Acceptance method until everything is allocated

## Detailed explanation

As stated above, the core of this allocation method is the deferred Acceptance method. How it would work in practice, the registrar’s office would ask either the professor or the person in charge of the class what type of rooms they would like to have, order by strict preference.

Once this is done, the algorithm has in memory all the rooms, their type and their capacity. It is a professor proposing DA, and they propose to the type of room. Once all the proposals are taken, the following process is ran for each room type. The rooms are ordered by declining sitting capacity, and the proposals are pooled. The rooms then one by one evaluate the fit they have with the courses, and the best fit is allocated. The course is removed from the pool, and the next room chooses. Once all the rooms have chosen, the courses that have a room are removed from the pretendant list.

The remaining pretendants then try their next choice, all the proposals are pooled including the current occupant if there is one, and the fit evaluation is ran once again.

This circle continues until everyone has a room or all the choices of the professors have been tried. If there are courses left without a match, the registrar’s office will allocate the remaining classrooms, or reschedule the courses if possible.

# Properties

### Strategy-proofness

Both the cohort size and the room size are final and are a given from the school system and registration. A buffer of 5 places to account for class switches can also be added to remove any idea of asking for a bigger room to account for this phenomenon.

The priority queue uses absolute size comparisons as well to remove any arbitrage or strategy possible from efficiency ratios.

Deferred Acceptance is generally strategy proof for the proposing side, and here the rooms have no strategy as they are based purely on an immutable physical characteristic.

If we consider the teacher C. Among the rooms where C fits (s ≤ capacity):

* If C gets its kth choice by reporting truthfully
* Listing a less preferred room earlier won't help because:
  + Either a larger course already has that room (and will keep it)
  + Or no larger course wants it (so C could have gotten it anyway)
* Listing a more preferred room later won't help because:
  + If C could get a more preferred room, it would have gotten it by proposing earlier

### Stability

The system achieves stability through the properties of the deferred acceptance structure, and both rooms and teachers have strict preferences.

No blocking pair can exist because:

* If teacher A prefers room X, it must have already proposed to it
* If room X didn’t accept A, it has a better-fitting teacher
* Therefore, A and X would not agree to form a blocking pair

### Pareto Efficiency

The system is pareto efficient as it continues until not further improvements are possible. Each teacher proposes to rooms in a strict preference order, and rooms accept the best-fitting teacher they’ve seen so far. Therefore, the final matching cannot be improved without making someone worse off. Moreover, the teacher proposing DA makes it optimal for teachers.

### Individual Rationality

This property is granted by respecting preference lists

# Questions answered

### preference of the rooms ?

Based on capacity, based on the cohort size versus the size of the room, maxed out at 5 students less than the room (based on registrar's office numbers), if equality the professors whose choice was the worse last time around is chosen. If not existent or still equality, flip a coin.

### how to avoid congestions in serial dictator ship ?

The serial dictatorship is ran by the registrar's office based on the rooms that are left until everyone has a room.

### student preference take in account ?

student preferences are not taken into account, or at least not in case of tensions, when there are multiple rooms stills left open when all the courses have been assigned we can allocate preferably to those rooms

### Survey to make sure professor have preferences ?

They do, or at least a enough do that they could benefit from the system

### wouldn’t everyone have the same choice ?

They might, but they also might not, in any case this would make it so that the classes with the most students get the most requested rooms, so we maximize their rooms. Made a survey regarding the students.

### how to ensure teachers will not lie ?

Safety, Simplicity, fairness and stability of the algorithm, no incentive to lie as this version is nearly strategy proof.