

# An Automated System to Distribute Students to Clerkships

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**Abstract.** Participating in clerkships with general practitioners (GPs) is integral to studying medicine. The students gain deep and valuable insights into the everyday working practice of GPs. The central challenge is organizing these clerkships to distribute the students to the participating doctors' offices. This process becomes even more complex and time-consuming if students can state their preferences. To support faculty staff and involve students in the process, we developed an application to support the distribution process via an automated system and applied it to allocate over 700 students over the course of 2.5 years.

**Keywords.** Medical education, automated allocation, clerkships, application development

## 1. Introduction

An integral part of studying medicine is gaining hands-on experience in direct contact with patients. Within the block course in general medicine, students at Hannover Medical School complete a clerkship in one of the participating doctors' offices [1]. In the past, students were manually assigned to offices by faculty members. This task can be challenging depending on the number of students matched to the limited number of available offices in Hannover. Since students cannot simply be sent to places far away from home, they were asked to state three preferences for doctor offices. Empirically, most wish to remain in Hannover, which is only feasible for approximately 30%. This led to many student complaints and the need for time-consuming communication.

We intended to improve the distribution method, factor in the students' preferences, and present all participating offices and corresponding information more efficiently. Specifically, the objective of developing the system presented here was to tackle the allocation and information problem based on algorithms offering automated distribution of individual students to GP offices. An additional aim was to simplify documenting the allocation process. Also, the relevant information about the offices needs to be presented

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adequately to the students to let them inform themselves adequately. The system should also motivate students to visit practices that are less popular than others.

## **2. Method**

Discussions among the authors and with the general medicine staff helped design a system that addresses the abovementioned challenges. As described below, the application developed in this context allows instructors to communicate information about available doctor's offices more efficiently and students to learn about them. The system tracks the students' preferences and then assigns them to an office.

### *2.1. System Design*

We developed the application as a web-based service based on Microsoft's ASP.NET Framework, using the C# programming language. It is comprised of two main parts. The core system provides the functional components of the application. Business logic and persistence are in this part of the application. Functions of the core system are accessible via an application programming interface. A web front-end is used to meet the needs of the lecturers and students. The system uses the authentication methods of existing e-learning organizational infrastructure to facilitate login using the SOAP interface provided by the local installation of the Open-Source ILIAS learning management system (LMS). After successful authentication via the LMS, a session for the individual user is started on the system's server component.

### *2.2. System flow*

To get the system started, an import function allows instructors to load information related to the available doctor offices from an external system (SharePoint, which provides this information) into the application. A data format compatible with the external system allows easy import by exchanging a single file. Afterward, the application is ready to be deployed to students to enable them to start their selection process. The faculty members do not have to provide further input or parameters. Once students are logged into the system, they are given detailed information about the following process. After acknowledging the introductory information, students are directed to the overview page listing the participating doctors' offices, providing essential information for a quick overview. There are around 150 offices to choose from. Further information is provided on a detail page for the respective office. The imported details given here are the contact person's name, a link to the website, the address, a description of how to get there, and information about possible accommodation.

If students are interested in a doctor's office, they can add it to their selection by clicking a button. They are then forwarded to an overview page on which selected offices are displayed, with the possibility of ranking their choices. If students do not choose a ranking, the last added office will be defined as the first choice. The order can be altered at any time, which is critical for the distribution algorithm. The system can be configured so that only a maximum number of practices can be selected. If the maximum number is reached, the student is prompted to replace one of the existing practices.

To give students an overview of which doctors' offices have already been selected by others, a kind of "traffic light system" has been implemented. A green indicator shows

that another student has not chosen this doctor's office so far. If there is a yellow indicator, another individual has already selected the office, and the current student's chance to actually book the office is significantly lower.

### *2.3. Algorithm*

After a predefined date, students may no longer input their choices, and the distribution process starts. The process is iterative and includes all participating offices. At each iteration level, for each office with a "first choice" selection by any student, the students are assigned accordingly. If more students are interested than there are possible places in an office, a random sample of students with that choice is made depending on the number of available slots. After allocation, the loop continues. Once all top-choice offices have been processed, the already assigned students and offices are discarded. For the remaining students, the second choice becomes their first choice, and the process begins anew. This iterative process continues until no more students are left, or the number of students no longer decreases. This makes it possible to respect the students' first choices better and shows why it is advantageous for students to choose a practice that is not in high demand, thus significantly increasing the likelihood of being assigned to an office of their choice.

After completing the automated allocation procedure, the results can be exported as a list. The list contains information about the placements and the contact persons. Later, this list can be used to prepare letters informing students about their placements. Along with the finalized assignment to a specific doctor's office, the list also states the initial choice of the respective student. In combination, this information is crucial for distributing the remaining students, for whom no clerkship placement could be achieved via the automated process, to one of the remaining offices. The allocation of the remaining students remains manual (instead of random assignments), making it easier to work out suitable placements with the students. Once all students have been assigned, they are informed about where they have been placed.

## **3. Result**

According to limited direct, unstructured (verbal) feedback provided by several students to the general medicine staff, the students appear to appreciate the automated procedure. Students feel they are treated more fairly and actively involved in the process. A more detailed, structured evaluation is pending. So far, the system has been used for a duration of approx. 2.5 years for more than 700 students. As reported by the faculty, a considerable amount of time was saved compared to the previously employed process. However, the exact amount is difficult to quantify, as the online system offers more possibilities than before. The timespans required for the manual procedure (which included more back-and-forth communication with the students) were not recorded for later evaluation. With the online system, the students' wishes no longer had to be collected manually. In the old manual process, such choices were generally not even considered in the assignment process, as doing so would have taken too much time.

The staff emphasized that the allocation procedure has a less arbitrary character, which improved acceptance of the process among the students. The range of assigned offices has also increased, as students are now choosing offices not previously considered by the staff performing the manual allocation.

#### 4. Discussion

To our knowledge, there has been no previous description of a system enabling similar resource allocations in medical education with an open design. At most, the login process and importing information related to the GPs' offices would need to be adapted to allow for integration at other universities. Our system has served its intended purpose well and is a solid base for further developments. Ongoing work is dedicated to expanding the system with functions that enable even better integration into everyday student life. This includes, e.g., a direct synchronization with the existing database of doctors' offices, which would make the intermediate step of importing and exporting data redundant, as experience has shown this to be error-prone. Current limitations include that it is not always possible to distribute all students as desired during the automated assignment. This is because no minimum number of selections is required, and sometimes, students refrain from making any choices. One solution would be a simple random distribution of the remaining students, but other allocation methodologies may also be worth considering. For example, the Kuhn-Munkres algorithm [2,3] has already been experimented with as a weighted assignment problem on bipartite graphs. It is, however, questionable whether this method is "fair" (in the sense of providing equal opportunities) without implementing additional requirements (e.g., a minimum number of selections) during the selection process. In turn, this might positively or negatively impact the motivation of students to choose practices outside of popular urban centers. Functions to further support the students in their choice will be added soon, such as displaying more attributes, e.g., the languages spoken in that location. Additionally, the aim is for the teaching staff to be able to use the system entirely on their own; currently, the automated allocation process is still being started by the developer once the deadline for making a choice has passed. Communicating assignments to students, which still relies on lists that the students must check regularly, could be significantly expedited if emails were used. Aside from improving speed and comfort, data protection might also benefit, as only the respective students would receive the information about their assignments.

#### 5. Conclusions

The presented online data capture and distribution tool allows for an efficient and fair distribution process that maximizes our students' satisfaction and replaces the previously manual process. On a final note, the problem of allocating students to available teaching resources may be similar for others active in medical education. In the future, the project will be opened to those interested in applying our methodology for this purpose once we have properly evaluated the system via user surveys that are currently being planned.

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