UniDash: Interactive Dashboard for Data Driven Insights on Universities

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Abstract: Universities, like other institutions or companies, are under steady quality control in pursuit of improvement. Generating pertinent insights from consistently collected data at universities is one of the many possibilities to integrate data science into our educational system. The proposed prototype dashboard is designed for educational institutions to visually assess their shifts in relevant topics such as diversity, accessibility, and planning aspects. This paper shows the workflow and dashboard using the UnivIS database of Kiel University for extracting and preprocessing the data. The proposed demo revealed interesting insights, such as how, in the planning stage, lecture halls are selected with only 50% capacity utilization; rooms for fewer than 50 people are planned to be used at 100% capacity. The demonstration web application can be tested in German at `unidash.tk`.

Keywords: interactive dashboard; academic advising; data-driven decision-making

1 Introduction

In the past decade, it became of paramount interest to assess and improve the quality at universities, leading up to tackling the required changes as described by Baker and Lenhardt in [BL08]. In order to evaluate development, one must be able to measure and trace numbers describing the feature of interest. However, collecting data is only the first step to extracting valuable insights. Data scientists are trained to compare and visualize the generated data. To perform quality evaluation on complex questionnaires, and working groups are required, which are laborious, and demanding of time and monetary resources. Department heads of large institutions like universities often lack the time to set up these complex evaluation tools for their institution. Therefore, we approached the challenge and developed a dashboard showcasing the progression of a university using its own data collected over the past 20 years. We developed a workflow for extracting the data from open-source tools and implemented a dashboard, making the shifts in the data clearly traceable. The derivable insights range from the capacity utilization of classrooms to the percentage of accessible classrooms used by each department.

Data mining is increasingly utilized for meta-evaluation in the academic world, for example, the assessment of the student body [Th22], [Gu20], or optimizing teaching methods [MJ12].

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The untapped potential of using academic data in the education system is further analyzed in [We12] and [Fi20], concluding that incorporating data mining will enhance informed decision-making, leading to optimized teaching effectiveness. This demonstrates the growing significance of mining the available data in educational systems. In this paper, we propose a workflow and prototype dashboard to visualize patterns and trends in data from Kiel University. The main contributions can be summarized as follows:

- Workflow for the extraction of data from a university management system
- Dashboard with interactive visualizations

2 UnivIS Data

Large institutions like universities have to solve complex planning problems every semester. The solution must combine human resources, room vacancies, and examination regulations to name just a few of the constraints all timetables must fulfil. To combine all the required information, multiple database services are used in the German network of universities. Like the universities of, e.g., Erlangen-Nuremberg, Bamberg, and Lübeck, Kiel University uses UnivIS [STU99] to store the relevant data for the planning of the semesters. UnivIS is a relational database, with an API to extract data as XML. The database schema is adapted for the university process, to seamlessly combine teaching, room and human data. Through multiple API requests, [Ki22b], we were able to pull all of the collected data. We merged the XML responses into a local SQL database using the same scheme as the UnivIS database. In combination with UnivIS, Kiel University's Department of Computer Science uses a module database (the ModulDB) to store additional details regarding their courses. Data from both sources were gathered for the dashboard.

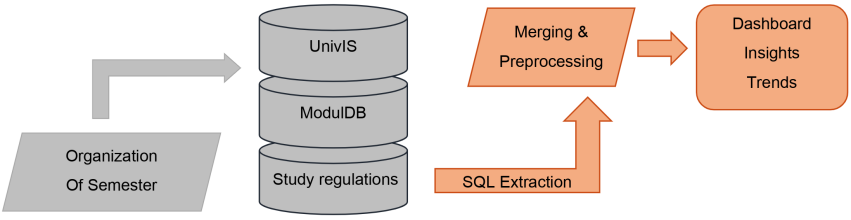

Fig. 1: Workflow of generating the dashboard, grey fields: implemented processes at universities, orange: our implemented contribution

3 Dashboard

The implemented dashboard is designed for universities to showcase their strengths and weaknesses in a customized open-source application. It targets universities to enable them to

get a clear view of their own position on a variety of current and relevant aspects. Because the application uses existing data sets the dashboard can also reveal past developments. The proposed workflow is shown schematically in Figure 1. Steps that have already been taken at the universities are drawn in grey. The orange steps entail our contribution built upon the available databases.

On the dashboard, there are currently nine topics visualized. Each topic is designated to a research question in a timely fashion. In this paper, we explain the following four questions in more detail.

- Are the rooms used according to their capacity?
- How wheelchair accessible are the courses of different faculties? Is wheelchair accessibility evenly distributed across faculties?
- Can students reach their classes on time, or are locations too far apart? (Exemplary for two subjects of study)
- Kiel: 'Best Prof' Award voted by students. What insights can be extracted from past winners?

4 Technical details

UnivIS Kiel provides a public API, [Ki22b], supplying the required data for this dashboard. As a result of the database being maintained and data being inserted manually, one has to presume many errors regarding spelling, coherence, and missing values. This was especially problematic when working with the addresses for classrooms. From abbreviations for buildings, misspelled street names, and missing zip codes to lacking street numbers, all possible errors had to be caught. Using regular expressions, almost all addresses could be extracted, but this required expert knowledge of the university community, mainly concerning common abbreviations.

Regarding the dashboard deployment, the Python library *plotly* [Pl15] was used for easy and fast implementation. This also allows for simple modification and transfer to other universities with few requirements of HTML and CSS knowledge. The code, including the SQL requests for extracting from UnivIS, is available on a GitHub repository. [3]

5 Demonstration

Using the example of Kiel University, the dashboard can be viewed in German at `unidash.tk`. The elaborated topics are presented in separate tabs, where one or more interactive graphs visualize the corresponding data for the different departments and semesters. The navigational toolbar on the left leads to the different topic pages.

[3] https://github.com/doubleblind44/unidash

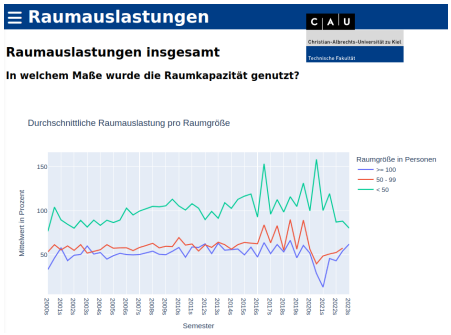

Fig. 2: Used capacity in percent of different room sizes over the semesters

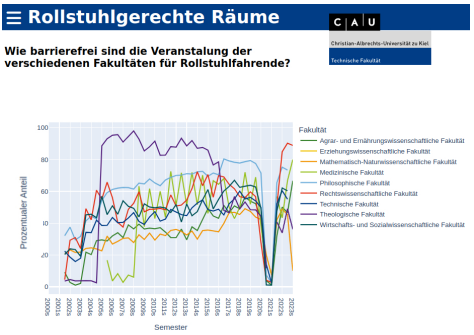

Fig. 3: Percentage of accessible rooms per department per semester

Room sizes The question of room planning is of ongoing interest due to the exceeding heating and lighting resources required for larger rooms, [Ki22a]. Are the rooms used to full capacity, or could events be held in smaller rooms? An excerpt from the dashboard for this topic can be seen in Figure 2. The rooms are grouped into three different categories, according to the number of people they can host. This distinction showcases that, based on the room size, there is a marked difference with respect to the used capacity. Rooms with fewer than 50 seats are often used up to 100% capacity or even more. Larger rooms (>=100 seats) on the other hand are often only 50% occupied. For this evaluation, the *turn out* parameter, a value describing the planned number of attendees for the module, is used. It is relevant to keep in mind that student attendance for lectures is often hard to estimate beforehand. Therefore, it is necessary to allow for a buffer. Based on the obtained insights, the administrative instances of the university can make an effort to determine the actual capacity of the rooms during the semester in order to determine whether this discrepancy could be a starting point for energy-saving improvements.

Accessibility The university strives for inclusiveness and fairness to ensure equal opportunities for all its student. This also includes wheelchair accessibility. The wheelchair accessibility of modules is documented as a flag in the database. The accessibility of the different faculties is depicted in Figure 3. The plot reveals how many faculties courses are, on average, located in wheelchair accessible rooms or even buildings. Drastic shifts in the percentage mostly correlate with changes in the locations of faculties. As an example, the Faculty of Law ('Rechtswissenschaftliche Fakultät') moved into a new building in 2021. The difference is obvious when comparing the values before and after the COVID-19 pandemic. Large jumps in the early years, e.g., in the winter semester 2004/2005 (2004w) for the Faculty of Theology ('Theologische Fakultät') suggest that the flag was not used in the years before 2005. As all events during the pandemic took place online, classified as

non-accessible, an overall drop is observable in the winter semester 2020/2021 (2020w) and summer semester 2021 (2021s).

Walking distances When creating lecture plans, the distances between module locations need to be taken into consideration. For this dashboard, the compulsory modules for selected semesters of two subjects of study were gathered, and the locations were visualized on an interactive map. The goal was to detect cohorts that were spread out far and evaluate whether the distances could lead to time conflicts in the semester schedules.

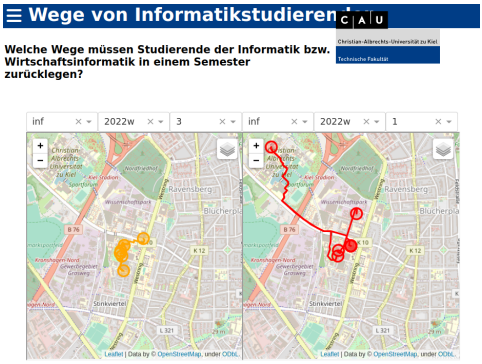

Fig. 4: Locations of compulsory modules for computer science semesters 1 and 3 in winter semester 2021/2022

In Figure 4 the comparison of two chosen degree programs and semesters is depicted. Additional data on the compulsory modules for the semesters had to be acquired manually. Because this information changes frequently, it is not stored in UnivIS but recorded in the examination regulations. Manual evaluations revealed that some modules could not be chosen in certain semesters due to time conflicts. With further development, this could be expanded into a tool for automatized checking of time conflicts and added into the planning process.

Best Prof At Kiel University a 'Best Prof' award[4] is given by vote of the students in the Department of Mathematics and the Department of Computer Science every year. The dashboard traces the lectures of the past top three winners of each year. Two excerpts of the evaluated statistics are shown in Figures 5 and 6. According to these analyses, past winning professors held noticeably fewer modules on Monday, Friday, and Saturday than the other days and started their courses mostly at 8 a.m., 10 a.m., or 12 a.m.

These findings were used to predict the top three candidates of 2022. With the above-described filters, two of the three professors on the podium could be predicted correctly. The professor in third place did not fit these insights as multiple modules were held on Monday. This got the better of our logic and proved: Preferences cannot be predicted purely on statistics. If you teach well, students will appreciate it, despite the course being held on Mondays.

[4] https://www.fs-infmath.uni-kiel.de/wiki/Best-Prof-Hall-of-Fame

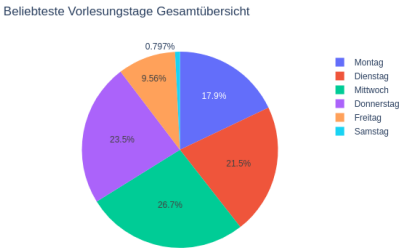

Fig. 5: Lecture days of modules from past winners

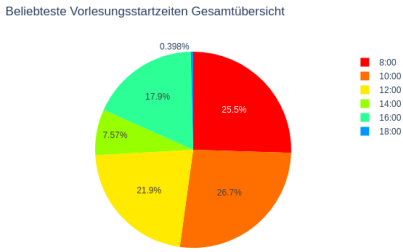

Fig. 6: Starting times of modules from past winners

6 Conclusion

The proposed dashboard provides insight into the evolution of Kiel University and shows the benefits from reaping the database systems in place. By using an already existing database, this project was implemented with little necessary effort on the part of the university. Thereby, this prototype is a feasible solution for interactively analyzing a large institution where the gathering of data is often complicated and faces bureaucratic difficulties.

To transfer the dashboard to other universities, it is essential to extract an equivalent data set from the system in place. Additional topics, that can be analyzed and added to the dashboard are only limited by the data available. The proposed dashboard contains a baseline of evaluations for answering the chosen questions of interest for large institutions regarding the progression of room utilization, diversity, and inclusiveness. Further evaluations are implemented in the prototype dashboard that could not be explained in detail here due to brevity. The evaluations and insights are described in German on the demo web application.

Caution has to be exercised when drawing inferences from the data because the data used are planning data and therefore do not always depict a true representation of the real conditions at the institution. A strong example is the decision to flag online events as non-accessible, resulting in a seemingly very retrogressive development concerning accessibility in the semesters during the pandemic.

As for the evaluation of Kiel University, in the demonstration, we showcased the strong suits such as the rise of wheelchair-accessible rooms, and make the potential for reasonable areas of improvement visible. Answering all chosen questions with data visualizations. We aim to make this dashboard easily transferable to other universities in the future to gather insights into their performance. Furthermore, we plan on providing additional features, such as advanced room planning, to reduce unnecessary heating costs. We are convinced that interactive platforms, like the one proposed in this work, bear the potential to pave the path for accelerated and improved performance assurance in universities.

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