Data Manipulation and Visualization (DMV): A Case Study

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Abstract - Academic Program Directors (APDs) at various academic institutions are required to manage a specific program with the understanding that APD will not only maintain currency of the courses in the program but will also provide academic advising and manage student enrollment in the program. However, because of larger enrollments and frequent offering of the program, at times, it becomes very difficult to complete and manage all of the responsibilities. The advances in technology offer the efficient use of large amount of data for more objective and better decisions. In this paper, we investigate the design for information visualization through an interactive application using Tableau. The use of Data Manipulation and Visualization (DMV) helps APD to keep track of student progress and their enrollment history through user-friendly reporting and data visualization. The paper also presents additional tools for analyzing data and visualizing interaction histories that supports data analysis and communication of findings.

Keywords: Tableau, Data Manipulation, Data Visualization.

1 Introduction

Higher education sector has increasingly begun to pay more attention to academic leadership, since it plays important role in offering good quality and sustainable programs. Among academic leadership one group who has a significant role to play in offering high quality programs is the Academic Program Director (APD). Academic Program Directors in their role are responsible for coordinating and managing degree courses in the program [1]. The challenge for the APDs is that, in addition to having academic credibility they must lead and manage the faculty teaching in the program, in most of the cases, without having any management authority. Program management can be difficult and stressful for everyone involved, but a successful APD can ultimately help the institution thrive by not only managing good quality programs but also students in the programs [2]. Academic Program Directors (APDs) at various academic institutions are asked to manage a specific program with the understanding that APD will not only maintain currency of the courses but will also provide the academic advising to the students in the program. In general, APD will ensure that curriculum in the program is current, program is offered at regular intervals and that the students are taking courses in a sequence following a predetermined prerequisite structure. However, because of large enrollments and frequent offerings of the program at times it becomes very difficult to fulfill and manage all assumed responsibilities.

In recent years, use of management systems have become an important tool for an effective leadership and data-based decision making [3] that could certainly help APDs. At times, academic institution uses different systems to manage student and program related data, leading to various sources of data that make managing analysis and reporting requirements across various systems very challenging. APDs would also need data management and visualization tool to further improve decision making in all aspects of program management. Our objective for the case study is to design a system that eases this task by allowing anyone to perform sophisticated education analytics and share their findings. In order to make a quick and learned decision the use of Tableau is explored in this case study. Tableau is a data analytics and visualization tool used widely in the industry today, many businesses even consider it indispensable for data-science-related work. The use of Tableau does not require any prior programming experience and its ease of use comes from the fact that it has a drag and drop interface and being user-friendly it is suitable for any kind of user, ranging from data scientist to manager. Tableau is also compatible with multiple data sources, including Excel, SQL Server, and cloud-based data repositories which makes it an excellent choice for Data Scientists [4]. Tableau visualizations are interactive and shareable, helping user to get answers promptly. It also allows Excel users to keep their spreadsheets while greatly enhancing their ability to analyze their data while delivering simple to build, simple to read visualizations that convey information clearly. In addition, Tableau as stated before, also has a very intuitive graphical user interface with drag-and-drop option which makes it possible to create charts, tables and other visualizations with just a few mouse clicks. Moreover, Tableau requires no additional packages for mapping and statistics as these features are built in the software.

2 Existing Setup

The existing system available for APD support although is computer based but requires lot of manual work in order to retrieve any useful information that can later be used for making any program related decision. Following is the list of some of the shortcomings of the existing system;

- APDs having difficulty in getting status of program prerequisite courses.
Existing system and the process used by APDs has few loop holes that will result in students to slip through the cracks and take courses without completing prerequisites, among various other issues. APD may get contacted in this regard towards the end of program when students apply for graduation, thus making the situation very complicated for APD. The program used for this case study is a graduate program, that is offered three times a year and each offering is called a String. In some cases, students are registered and start the program in one String and somehow, student moves from one string to another String and somehow, student moves from one string to another string and take courses according to their own convenience, rather than following recommended sequence. The program also has three program prerequisite courses for students who do not meet admission criteria. In addition, the way the existing system is set up, APD needs to log in to different university portal to look at an individual student’s enrollment summary to determine if he/she has taken the required program and/or course prerequisites. In the case a student skipped prerequisite APD must first search for the students’ admission advisor and then contact him/her to get the details as to why student skipped prerequisites course(s). There are many possible reasons why a student may not be required to register in the program prerequisite courses, such as, student satisfies admission requirements so do not have to take prerequisites and can therefore directly enroll in the core classes. It is also possible that sometimes a student transfer from other institute and hence receives equivalent transfer credits for prerequisites. On the other hand, student may have skipped prerequisite classes because of taking and successfully passing challenge exam for these courses. Therefore, in order to ensure all the students who, need program prerequisites and other students are following the courses sequence, the APD from time to time must complete the following time-consuming tasks:

- Check student enrollment history for all students registered in the first core course in the program to confirm that program prerequisite requirements have been satisfied.
- Check student enrollment history for all students in the program to ensure students are following the required prerequisite.
- At times APD would also like to ensure that all scheduled classes are staffed. For this APD will need to check the status of each class in the program one by one.

3 DMV System Design

Trying to use spreadsheets for advanced, responsive analytics or analyzing large volumes of data, is using the wrong tool for the job. We also understand that in such situations too often, mistakes are made at the expense of efficiency and accuracy in addition to hours of lost time. In response to address above stated concerns the design of DMV system is based on a reporting application that will assist APD or any other user in decision-making process by visualizing data and/or generating reports. However, for creating reports there are guidelines that need to be followed, since generating a unique report may be complicated so it is a necessity that all the relevant requirements are fully understood [5]. We have developed a prototype, close to be the final release product, as an initial model with an objective to evaluate our design [6].

The proposed DMV system consists of an interactive user interface that functionally allows APD to generate various interactive reports in order to keep track of student progress, student grades, and their enrollment history in different strings of the program. In addition, DMV will also list name of the faculty member and the name of the course that he/she is assigned to teach as well as list of courses that are not yet staffed with a faculty. Tableau filter utility can be used for generating reports by changing the contents of the data that may enter a Tableau workbook, dashboard, or view. Since Tableau has multiple filter types so each type can be used for a different purpose. It is important to know that one can change these filters and the order in which each of these filters is executed. The reports also provide interactive features like highlights to differentiate among specific scenarios. Following is a list of reports that APD can generate using DMV system.

Enrollment Status Report:
A list of all students in the program can be seen in this report. A click on the student name reveals enrollment and grade history of that particular student. The screenshot in figure #1 shows all the students and classes which includes prerequisite as well as core classes. The highlighted box indicates prerequisites courses details, the term in which the class was taken. When you want any specific student’s detail then click on his/her ID and it will reveal student progress report, described below.

Student Progress Report:
This report shows student progress in the program where APD can analyzes whole enrollment history of a specific student with just one click. This report shows all the courses that a particular student has taken, term for each class and the grades for each course. The grades for each course are shown as color codes. The name of the faculty assigned for each is also shown however, for confidentiality reasons we are showing Null for each faculty name. Figure #2 shows progress report for a student ID 579.
Core Classes Status Report:
This report lists core classes offered in all terms, as shown in figure #3. A click on any core class will reveal a list of registered students. In addition, it will also provide information about the faculty assigned to this class. Bottom of the screen you can find pre-requisite worksheet button. Core classes status report in fact, shows all the classes in one report for all the students.

Strings Status Report:
In this report APD can identify one of the strings for report generation using various options (Core classes, or students or prerequisite classes).
Moreover, from core classes status report we can also analyze student grades and terms of the classes from just one screen. ID in this report represents all student IDs, term represent the term (year and month) when student took the core class. Description represents the class name. A click on the term for example 1802, will reveal detailed information such as class name, student ID, and official grade for that student in this class.

Different filters can also be used to get specific information for a class. APD may want details about one class only for example, Modern Operating Systems which was offered in January 2018. In this case through the use of filters these details can be obtained. Just clicking on the term 1801 and one can get detailed information such as class name, student ID, and official grade for that student, shown in figure #4.

**Program Pre-Requisite Status Report:**
This report lists pre-requisite classes, identifying students who are registered in these classes as well those who are not registered, as shown in figure #5. The program pre-requisite status report is where one can visualize all pre-requisite class in one screen. ID represents student IDs, Term represent the term (year and month) when student took the prerequisite class. Description represents the class name. Distinctive shading boxes indicate students took the classes or not. Scrolling the course on the box, one can get detailed information such as course name, student ID and official grade for the student if he/she took the class.

![Figure #5: Program Prerequisite Classes Status Report with Student Grades.](image)

When APD wants to analyze multiple reports together, dashboards are the solution in Tableau. Here, we have created this dashboard to analyze prerequisite and core classes reports together. Moreover, filters are available to select different data according to our needs. For instance, figure #6 shows information for four students for analysis such as ID 57, 63, 149 and 530.

![Figure #6: Program Prerequisite and Core Classes Report](image)

From multiple report dashboard this dashboard one can analyze multiple data at the same time. For example as shown figure #6, student ID 57 did not take the first and third prerequisite classes named Introduction to Programming Concepts and Programming in Java and started taking core classes. In another example studentID 579 did not take any prerequisite and directly registered core classes, although there are many reasons for student not taking prerequisite classes. Some time students have bachelor’s in computer science so, they do not have to take prerequisites. Hence, they directly enroll in core classes, some time students transfer from other schools, and have already passed prerequisites. On the other hand, a student may pass the challenge exam for the prerequisite class(es) and thus do not need the prerequisite classes so can directly register in the core classes.

**Grade Report:** This report lists students who have received a particular grade for example A or A-, as shown in figure #7. The report shows student ID, Class Name, term for the class and faculty name teaching the class, for confidentiality reasons we are showing Null for each faculty name. The report can also be generated for all students and their respective grades as shown in figure #8. In order to analyze multiple reports together, dashboard is the solution provided in Tableau. For example, this dashboard can show all the details about progress report of multiple students at the same time. Similarly, we can analyze performance of all the students in a specific term as well as name of faculty assigned to each course. In addition, for any subject performances of all students can also be analyzed.
Term Report: This report lists students in all classes for a specific term. The report shown in figure #9 is for November 2017 term, has student ID, the class name and the term. The grades for classes are shown as color codes for the said term, if the class is not yet completed then no grades are shown for that class.

![Figure #7: Grade Report for a “A” Grade](image1)

![Figure #8: Grade Report for all students](image2)

![Figure #9: Term Report](image3)

4 Benefits of DMV System

Our proposed system can easily be adopted for any academic institution to visualize data and create various reports at the same time. DMV system will work for any data source, APD is however required to provide details about the program including prerequisite structure. This system has all the potential to be the academic program director’s most reliable asset. Some of the major benefits for APDs using DMV system are listed below:

- It will reduce the report generation time so that APD can make decisions in a timely manner.
- Get current status of all the students in the program by tracking student progress in real time.
- Track student case exception for students who have not followed the proposed course and program prerequisite structure.

5 DMV System Users

Analytic users are not all the same; in most organizations, there are a number of users at different levels with varying distinct needs. User persona for DMV system will be any user who wants to analyze and visualize data in addition to generating interactive reports. The primary user and
authorized user may be able to add and modify data and information. Following are possible DMV System users;

- **Academic Program Directors (APD):** One of the main users that holds a position that is responsible for managing all aspects of a program. In practice, APD tends to work with highly diverse problems and cannot always predict the nature of the problems that will need addressing. Therefore, APD places a premium on being able to use a wide variety of analytic methods, techniques and tools.

- **Program Faculty:** Similar in many respects to the Academic Program Director. Share interest in “Easy to Use” tools, and a desire to engage at a granular level with the data. Faculty believe that knowing their students well is fundamental to effective instruction.

- **Students:** Can utilize dashboards to keep track of their progress in the program as well as future class enrollment data.

6 Test and Conclusion

The goal of testing the prototype was to engage a sufficient number of potential end users with varying backgrounds and skill levels. These users helped to determine the level of ease of navigation and the overall effectiveness of the user interface designed for DMV system. Instructions for each task to be performed were given with minimal details to encourage the participants to use their own judgement to complete each task. The overall usability of the completed prototype as determined by the analysis of the usability test results, was measured at a very high level. The ease of use, clarity of steps as well as ease of locating the specified filters and analyzing proper data was reported by 85% of the users. On the other hand, 80% of the users rated overall system navigation as either “easy” or “very easy”. The test users were also kind enough to provide constructive feedback regarding areas of further improvement to further enhance the ease of use. Some of these suggestions were implemented in the revised prototype version. However, other recommendations required extensive changes and hence were postponed for future implementation.

This case study investigated program and student management by Academic Program Director (APD) through a Data Management Visualization (DMV) System. The results showed that successful use of the DMV consequently improved management of student enrollment and their progress in the program. This is realized through data-driven decision making; monitoring student registration, student performance and student activity in the program.

7 Future Add-Ons

Based on the test results from the use of the prototype additional functionality can be incorporated in the system. Followings are the add-ons for the future version of the DMV;

- Current system is only accessible on desktops and laptops. To make this system handy to analyze the report anywhere any time thus mobile and tablets access is planned for the future design.

- Current system works with a single data source. However, in case a user wants to connect system to different data sources and generate reports the system needs to be more flexible. This aspect is also planned for the future design.

8 References


