

Academic Advising System Using Data Mining Method for Decision Making Support

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Abstract—With the high drop-out rates of college students across the Sultanate of Oman, the government urges HEIs to undertake ongoing analysis of its student population profile and evaluate the effectiveness of their academic advisory services. It is for this reason that this study intends to introduce an Online Student Academic Advising System for higher education, particularly to the Oman Tourism College (OTC). The developed system facilitates academic advising activities and keeps track of student's academic performance. By utilizing data mining method, the system is also capable of generating the required data set that can be used for data analysis and data modeling to discover useful knowledge regarding students' profile, students' registration, and students' module marks. The results of data mining in graphs and tables are very essential for OTC to make timely decisions and implement appropriate actions. The study was carried out using several stages of Developmental Research Method. By utilizing Quantitative Methodology from close-ended statements of the feedback survey, student participants were asked to evaluate the compliance of the developed system in accordance to the Industry Standard Organization 9126-1 (SQUARE ISO/IEC 9126-1:2001) software quality standards. The results showed that the system is a significant improvement for OTC and had a high level of compliance with the established software quality standards.

Keywords—academic advising; data mining; software evaluation; decision making support; software quality standards; K-means clustering

I. INTRODUCTION

In higher education, academic advising is considered as an essential part of students' academic success. However, oftentimes, it is one of the areas of academic services that has been ignored or deemed unimportant by many students.

The academic advising of OTC is faced with several issues. These issues are considered barriers and problems to the overall advising process between the teachers and the students. Firstly, academic advising is an additional item to the teacher's tasks. Secondly, the quality of academic advising is also affected by the length of time that students are able to meet with advisors. Due to the high number of students per advisor, advisors tend to spend inadequate time with students. On further analysis of student's issues, it was found that majority of the students do not know their advisors or only met their advisor during the registration

period. Oftentimes, if they have personal or academic issues, they interact with advisors who do not have a full knowledge of the student's background and hence would only be able to give advice based on the information provided to them at the point of advising. Some students also resorted to taking unfounded information from peers. This results to students' poor academic choices and eventually, consulting an advisor to fix the issues.

The ability to recognize students' weakness and solving any problem that may confront them in a timely fashion has now become an ultimate priority among all educational institutions in the Sultanate. The staggering increase of student drop-outs has also prompted HEIs, particularly Oman Tourism College, to determine the reasons behind by taking advantage of computerization to profile students and understand their behavior and academic performance. Most HEIs are persuaded to undertake ongoing analysis of its student population profile in order to make significant decisions on the long-term planning and development of its student academic support services and facilities including the student academic advising.

The use of an online Student Academic Advising System can help the management in the decision-making activities through the provisions of visual graphs and diagrams of students who are struggling in their studies. The system can record students' evidences and analyze their progress throughout their academic career. It can also clarify the learning pathways that will be suitable for each students in accordance to the specific requirements of their course and in line with the college context.

The methods of Educational Data Mining (EDM) is intuitively applied to discover hidden information from large databases and improved the quality of the whole educational system. EDM can be applied to discover patterns and facilitate the decision-making process of learners, students, and administrators.

The study aimed to achieve the following objectives: 1) development of an online Student Academic Advising System (SAAS); 2) application of data mining process using the source data generated by SAAS; 3) produce data models to classify and group students according to academic standing; and 4) evaluate the compliance of the developed system according to Industry Standard Organization 9126-1 (SQUARE ISO/IEC 9126-1:2001) software quality standards

such as Functionality; Reliability; Usability; Efficiency; Maintainability; and Portability.

II. RELATED STUDIES

A. Definition and Styles of Academic Advising

Academic advising helps students to cope with the academic and personal challenges and direct them to the path of a higher education that they have chosen [17]. According to Winston & Sandor [16], a properly defined advising system would provide “*a systematic process based on a close student-advisor relationship intended to aid students in achieving educational, career, and personal goals through the utilization of the full range of institutional and community resources (p.8)*”.

Many literatures on academic advising have mentioned about various advising styles that teachers may adopt such as *counsellor style* (emphasis on personal issues), *schedule type* (emphasis on academic issues), or *teacher style* (emphasis on both personal and academic issues [16]. There are also other styles including *directing*, *coaching*, *supporting*, and *delegating*. Other authors have mentioned about *parenting style* of advising in order for the advisor to be more effective and get support from the students. Advising style varies from advisor to advisor and it can be understood as a method or a way of dealing the situation [16].

But other than the teacher's role, students are equally responsible to make decisions and fulfill the tasks in order to become successful with their studies. Students' interaction with campus personnel is crucial regardless if it directly face-to-face or online [9] and can be influenced by various context and elements in the campus [3].

B. Data Mining for Academic Advising and Decision Making

Many people believed that knowledge is power and this is what makes data mining very useful. It has the ability to bring relevant discovered information that is useful in making strategic decisions in order to succeed. The main goal of EDM is to improve the quality of education by extracting information from educational data to support stakeholders (management, teachers, students, and parents) make a better education-related decision [7][10][15].

Large databases like the enrolment data are also used to mine knowledge to describe the student academic performance. For example, the study of Osmanbegovic and Suljic [10] extracted data about the socio-demographic variables, achieved results from high school and from the entrance exam, and attitudes towards studying. In addition, the study of Zlatko J. Kovacic [6] used the data stored in the student management system from 2006-2009 of Open Polytechnic to explore the socio-demographic variables and study environment that may influence the retention or dropout of the students in New Zealand. The work of Mohammed Sarem [13] collected data from the undergraduate students of Taibah University College of Computer Science and Engineering (CCSE) and found the impact of the difference between the registered and gained credit hours on future learning behavior of the student.

In order to decrease the high rate of academic failure and improve student performance and the quality of education, a student advisory framework that uses classification method and clustering method was developed by Nagy, Aly, and Hegazy [8]. The intelligent system was capable of providing consultations to first year students on which education track they should pursue and recommending the ideal specialization that they should enroll. In the same manner, Shatnawi, Althebyan, Ghalib, and Al-Maolegi [14] successfully developed a system that allows students to register for classes according to their preferences. They called it a Smart Academic Advising System (SAAS) that generates rules that the target user can use to get recommendations about the course to register for the semester.

Several authors have also confirmed the value of integrating data mining into decision support. For example, the web-based decision support tool (the Online Advisor) of Feghali, T., Zbib, I., & Hallal, S. [2] attempted to solve technology-based “last mile” problem that helped advisors and students to make better use of an already present university student information system. With the Online Advisor, advisors can have all the information needed about the courses taken by each student, about the courses still to be taken, about the changes in the academic requirements as they are decided by the appropriate committee(s) on campus, and explore future options for a student.

In the same manner, the college completion model based on k-means clustering algorithm developed by Paz, Gerardo, and Tanguilig III [11] was utilized in the development of the proposed academic decision support system (DSS). The system utilized data from the university database while the client front-end ensures adequate presentation so as to reveal significant details and dependencies. The system can be used to automate the decision making process of administrators aiming to decrease the high rate of academic failure among students. A real case study in Isabela State University was presented using a dataset collected from 2009-2013

III. RESEARCH METHODOLOGY

A. Development of Student Academic Advising System

The research design for this study was Descriptive Research using Quantitative Methodology from close-ended statements of the feedback survey. The study was carried out using several stages of Developmental Research Method, a type of research that created knowledge grounded in data systematically derived from practice.

The design and development of the academic advising system followed a project methodology framework that served as a guideline to know what was compulsory to do in the project and how to manage the project from start to finish. It also described every step in the project life cycle.

B. Data Mining Approach

The Knowledge Discovery on Data (KDD) process diagram was further modified by Han, et. Al [4] in their book “Data Mining: Concepts and Techniques” to combine data integration with data cleaning as a pre-processing phase to

generate a data warehouse. Using data selection and data transformation process resulted to a consolidated and task-relevant data. See Figure 1 of the modified KDD process diagram.

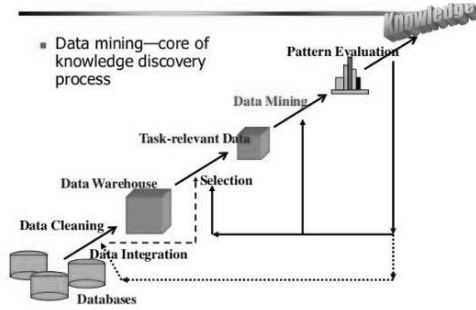


Figure 1. Modified KDD process diagram by Han, et al. [4].

KDD transformed collected raw data into some form of a new knowledge. The outline of the basic steps as mentioned by Han, et.al [5] is presented below:

- **Data Cleaning:** this is a process of data cleansing in which noise data and irrelevant data are removed from the collection.
- **Data Integration:** this phase combines multiple often heterogeneous data sources into one common data warehouse.
- **Data Selection:** this is the step wherein relevant and necessary data for analysis are selected and retrieved from the data warehouse.
- **Data Transformation:** this phase is where the selected data is consolidated and transformed into forms that are appropriated for data mining procedure.
- **Data Mining:** this is the most important step in which algorithms and techniques are applied to extract useful patterns.
- **Pattern Evaluation:** in this phase interesting patterns representing knowledge are identified and evaluated based on the given measures.
- **Knowledge Representation:** this is the final step in the process that uses visualization techniques to present the discovered knowledge and interpret the data mining results in a form that is easily comprehensible to the users.

C. Data Mining Algorithm Used

The study used k-means clustering algorithm to group students according to socio-demographic indicators (age, gender, nationality); course registration indicators (program, award, mode of study, semester); and module marks indicators (semester, module, grade, mark, and outcome). The discovered knowledge is useful in identifying the factors that influence student's progression rate. The results also served as basis in making academic support programs to address students' academic needs.

The K-means algorithm is the simplest and most commonly used clustering algorithm employing a square error criterion [11]. This algorithm partitions the data into K clusters represented by their centers or means. The center of each cluster is calculated as the mean of all the instances

belonging to that cluster. Presented in Figure 2 is the process model of the clustering algorithm.

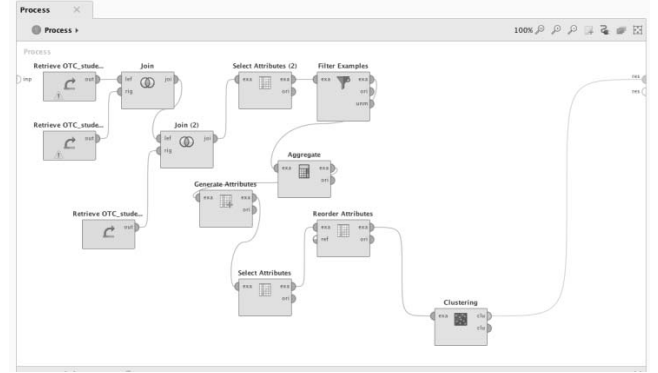


Figure 2. Process Model of Determining Students' Academic Performance using K-Mean Clustering Algorithm

D. Data Set and Attributes Used

The developed Student Academic Advising System generates data sources that are used for data analysis and data modeling. These source data are in CSV format that are fed into the RapidMiner software application. The data sets are composed of:

- **Student Information** – (college ID age, gender, nationality)
- **Student Registration** – (college ID program, award name, mode of study, level, semester, sponsor)
- **Student Module Marks** – (college ID, module, mark, outcome)

From the generated data sets, there were seven attributes selected and their data type is presented in Table I.

TABLE I. RELATED ATTRIBUTES AND DATA TYPES

Variable	Description	Data Types
Nationality	This determines if the student is an Local (L) or Expatriates (E)	Nominal
Gender	Student's gender. It determines where the student is male or female	Nominal
Award	This determines the award enrolled by the student whether (1) General Foundation Certificate; (2) Diploma; or (3) Bachelors with Honors	Numeric
Mode of Study	This determines if the student is studying (1) Full Time or (2) Part Time	Numeric
Program	This determines the award enrolled by the student whether (1) General Foundation Program; (2) Event Management; (3) Tourism and Hospitality Management (4) Tourism Marketing	Numeric
Scholarship	This determines if the students is a scholar by a Private Entity (P) or Government (G)	Nominal
Outcome	The result of student marks if (1) Pass or (2) Fail	Numeric

IV. RESULTS AND DISCUSSION

A. Developed Student Academic Advising System

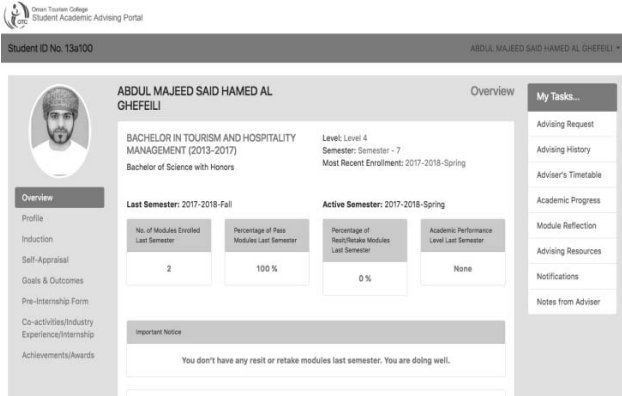


Figure 3. User Interface of Student Academic Advising System

The Advising Requests Module allows the students and advisers to set an advising appointment and agree for the specific date of advising session. An email is sent to the teacher and student once an appointment is created.

The Advising History Module tracks down the advising session details that have happened over the semester and the school year. It serves as a record keeping method to identify the cases and recommendations given to the students.

The Adviser's Timetable allows the student to view the work timetable of the adviser and know the availability of the adviser for an appointment to be set.

The Academic Progress Module allows the user to examine the student data individually and display the transcript of the student. It also allows the user to calculate the General Point Average and identify the modules to be enrolled on the next semester.

The Module Reflection Module shows the report of student marks from the previous semester. Students can put comments on the corresponding module before their advising meeting. It gives them an opportunity to reflect on the work they have done and the success that they have achieved.

The Notifications Module shows the list of advising appointment initiated by the advisers and students over a semester. It also shows the pending advising request for appointment.

The Notes from Adviser Module allows the student to view the overall assessment and impression of the adviser about his/her academic performance, attendance, and marks. This also allows the next adviser to have an overview of the advisee.

The Self-Appraisal Module allows the student to evaluate their own skills and qualifications in relation to the graduate attributes.

The Goals and Outcomes Module allows the student to set his/her priorities for the specific semester and it allows the adviser to gauge the progress that the student has taken in the attainment of the goal.

The Co-activities / Industry Experience / Internship Module allows the student to record the extra-curricular activities that he/she had accomplished.

B. Data Processing and Modeling

On the data mining approach, the researcher used RapidMiner Studio software application as the tool for extracting relevant knowledge from the source data. The data were first cleaned by removing missing and irrelevant values.

Row No.	NATIONALITY	Mode of Study	Award Name	Program	Sponsor No.	Outcome	GENDER	Total
1	Local	Full Time	Bachelor of ...	Tourism an...	Ministry of H...	Pass	F	2133
2	Local	Full Time	Diploma	Tourism an...	Ministry of H...	Pass	F	948
3	Local	Full Time	Bachelor of ...	Tourism Ma...	Ministry of H...	Pass	F	567
4	Local	Full Time	General Fou...	General Fou...	Ministry of H...	Pass	F	429
5	Local	Full Time	Diploma	Tourism an...	Ministry of H...	Pass	M	342
6	Local	Full Time	Bachelor of ...	Event Mana...	Ministry of H...	Pass	F	318
7	Local	Full Time	Bachelor of ...	Tourism an...	Ministry of H...	Pass	M	247
8	Local	Full Time	Bachelor of ...	Tourism an...	Private	Pass	F	207
9	Local	Part Time	Bachelor of ...	Tourism an...	Private	Pass	M	184

Figure 4. Statistics of the Sample Data taken from Fall Semester 2017-2018

After data cleaning and integrating the appropriate attributes, a total of 146 student records were taken as a sample from a total of 8,302 academic records of Fall Semester 2017-2018. As can be seen in Figure 2, majority of these students were studying Full Time in the Bachelor of Tourism and Hospitality Management Program. These female students were also scholars of the Ministry of Higher Education.

After using k-means clustering algorithm, Figure 5 and 6 present the output of the processing. The summary of cluster model is presented in Figure 5. In the model, there are two clusters: Cluster 0 and 1. These clusters represent the groups of students at OTC. There are 36 (25%) instances for cluster 0 while 110 (75%) instances for cluster 1.

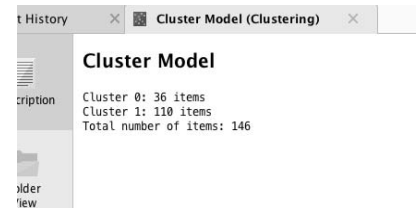


Figure 5. Summary of Instances Result

Attribute	cluster_0	cluster_1
NATIONALITY	1.056	1.164
GENDER	1.417	1.464
AWARD	1.361	2.718
MODE OF STUDY	1.361	1.264
PROGRAM	1.361	3.055
SCHOLARSHIP	1.361	1.427
OUTCOME	0.611	0.627

Figure 6. The Final Cluster Centroids After K-means Clustering Process

From the final cluster centroids, the initial starting points are:

Cluster 0: Local, Male, GFP, FullTime, GFP, Private, Pass

Cluster 1: Local, Female, Bachelor, FullTime, THM, Govt, Pass

Cluster 0 is composed of male Omani students studying full time in the General Foundation Program. Meanwhile, Cluster 1 is composed of female Omani Students studying full time in the Undergraduate Program and taking up Bachelor with Honors in Tourism and Hospitality

Management. All the students in both clusters have a good chance of passing the modules enrolled in the semester. It is interesting to note that majority of the student population belongs Cluster 1.

The resulting clusters are considered to be the model for decision-making support particularly in providing academic services and support programs for these student groups.

C. Software Evaluation

The developed system was evaluated by the students of OTC to determine the extent of compliance in accordance to the quality software standards. The online survey questionnaire was composed of Likert-Scale questions that adhere to ISO/IEC 9126-1 in terms of functionality, reliability, usability, efficiency, maintainability, portability.

The study used convenience sampling as the sampling technique. The students studying in the Fall semester of 2017-2018 were invited to answer the online survey using google forms. A total of 210 students have completely answered the online survey questionnaire.

The Weighted Arithmetic Mean was used to determine the average responses of each item of the five (5) options in each item in the Likert Scale questionnaire namely, 5 pts (Very Great Extent /Accepted Unconditionally), 4 pts (Great Extent /Accepted with minor condition), 3 pts (Moderately Extent), 2 pts (Low Extent/Accepted with major condition) and 1 pts (Very Low Extent/Reject). Table II is used as a guide to determine the acceptability of the newly developed system.

TABLE II. RANGE OF WEIGTED MEAN AND ITS INTERPRETATION

Range of the Weighted Mean	Interpretation
4.20 – 5.00	Very Great Extent (as a computer user) Accepted unconditionally (the Proposed System)
3.40 – 4.19	Great Extent (as a computer user) Accepted with minor condition (the Proposed System)
2.60 – 3.39	Moderately Extent
1.80 – 2.59	Low Extent (as a computer user) Accepted with major condition (the Proposed System)
1.00 – 1.79	Very Low Extent (as a computer user) Reject (the Proposed System)

Table III shows the results of the student participants' evaluation of the developed system's compliance with the quality standard characteristics as defined by ISO/IEC 9126-1 in accordance to functionality, reliability, usability, efficiency, maintainability, portability.

TABLE III. DETERMINING THE EXTENT OF COMPLIANCE OF THE DEVELOPED ACADEMIC ADVISING SYSTEM USING DATA MINING METHOD WITH THE QUALITY STANDARD CHARACTERISTICS AS DEFINED BY ISO/IEC 9216-1

Attributes	Sub-Attributes	Mean	Category Value	Description
Functionality	Suitability	4.13	4.25	Very Great Extent
	Accuracy	4.23		
	Interoperability	4.40		
	Security Access	4.23		
	Maturity	4.32		

Reliability	Fault Tolerance	4.20	4.15	Great Extent
	Recoverability	3.95		
Usability	Understanding	4.37	4.40	Very Great Extent
	Learnability	4.60		
	Operability	4.24		
Efficiency	Time Behavior	4.16	4.11	Great Extent
	Resource Behavior	4.05		
Maintainability	Analyzability	4.47	4.33	Very Great Extent
	Changeability	4.26		
	Stability	4.26		
	Testability	4.32		
Portability	Adaptability	4.47	4.24	Very Great Extent
	Installability	4.37		
	Co-existence	3.95		
	Replaceability	4.05		
TOTAL			4.24	Very Great Extent

With an overall category value of **4.24**, the participants, as a whole, characterized the developed system as compliant to a **very great extent** with the software quality characteristics.

V. CONCLUSION AND RECOMMENDATIONS

The development of the online advising system has benefitted the students and academic planners. Students are properly informed about their academic standing in the early part of their studies and academic planners are able to make necessary decisions and design better strategies for early intervention. This study can also help the college in providing better educational services for the students from the time they do the first registration until completion of their degree. The system can also formalize and standardize the academic advising services and evaluate the academic student support services on a regular basis. This shall facilitate the planning of services and guide actions for improvement. As mentioned by E.Y. Angeles [1] that the ability to monitor the students' progression is important for an academic institution to be able to help the nation build its human capital to enable it to actively participate in the global economy.

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