Understanding the Postgraduate Education Market for Better Marketing and Decision Making: A Clustering Analysis

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ABSTRACT

Enhancing the educational corporations is truly challenging mission due to the highly competitive nature of the business. Currently, there is emerging development within organizations to capitalize on their internal resources. This paper is taking data mining approach to strategize marketing for postgraduate studies by means of cluster analysis. The experiments were carried out using Oracle Data Miner tool, results are analyzed and discussed.

General Terms:

Educational Data Mining

Keywords:

Oracle Data Miner, Statistical Analysis, *K*-means Clustering

1. INTRODUCTION AND RELATED WORK

Because higher education is an essential factor for developing the society, it is imperative for learning institutions to invest time and resources in marketing the educational programs. As the number of universities increases dramatically, a very competitive environment has emerged among all the institutions to attract potential students. The main challenge remains on how to make use existing local resources, the very least the student application database.

Studies accomplished in the field of educational data mining present numerous case studies attempting to improve the educational experience according to the organization's perspective. The data mining approach in general begins by analyzing the available data and choosing the appropriate methods to extract the hidden patterns that is potentially useful to develop that organization.

Work by Romero and Ventura [6] present extensive review on educational data mining research efforts in the span of ten years; between 1995 and 2005. The same team [7] has also conducted a survey about the relevant studies carried out in the educational field relating the types of users and types of educational data provided. The data mining approach in [8] focus on three different predictive analysis, which are the neural network, logistic regression, and

decision tree. Other algorithms in data approach include *K*-means clustering [1], association rules mining [4], as well as decision tree [3]. Overall, the research attempts to predict student enrollment, to discover factors that impact the academic results among students or to analyze students characteristics based on their preference choice during registration at the university.

This research investigates the data from Universiti Putra Malaysia (UPM) regarding the postgraduate applicants, which includes Master and Ph.D candidates. The applicant database consists demographic information such as age, citizenship, gender, marital status; as well as field of study or domain-related information such as program applied and program offered. Clustering analysis is performed together with statistical methods for comparison purposes. The goal is to understand characteristics of the program applicants and distribution of the data, in effort to offer better education quality, better long-term investment plans, and more efficient targeted marketing.

The remainder of this paper proceeds as follows. Section 2 presents the cluster analysis for postgraduate education market, Section 3 details out the experimental setup, Section 4 discusses the results, and finally Section 5 concludes with some indication for future research.

2. CLUSTER ANALYSIS IN POSTGRADUATE EDUCATION MARKET

The objective of this paper is two-fold. First is to build a descriptive statistical model that describes the attributes that are most important to the university management and the relationships between one attribute with regards to the other attributes. Second is to use the descriptive data from the statistical model to perform clustering analysis in effort to help the university management for the same matter.

In data mining, the process of grouping a set of physical or abstract objects into classes of similar objects is called clustering. A cluster is a collection of data objects that are similar to one another within the same cluster and are dissimilar to the objects in other clusters. A cluster of data objects can be treated collectively as one group and so may be considered as a form of data compression [2].

The most commonly discussed distinction among different types of clustering is whether the set of clusters is nested or un-nested, or in more traditional terminology, whether it is hierarchical or partitional. Partitional clustering divides the set of data objects into non-overlapping subsets (clusters) such that each data object is in exactly one subset. If the clusters are permitted to have sub-clusters, then it is essentially a hierarchical clustering, whereby a set of nested clusters are organized as a tree. This research employs two clustering algorithms based on partitioning and hierarchical methods.

2.1 Dataset

The dataset under study is sourced from postgraduate applicant database in Universiti Putra Malaysia (UPM). Table 1 shows the selected attributes from the database under investigation.

Table 1. The applicant table.

Selected Attributes
ID
BUMISTATUS
CITIZEN_ID
LEVEL_OF_STUDY
CITIZENSHIP_STATUS
CHOICE1_APPLIED_ID
PROGRAM_OFFER_ID
DOMAIN
RELIGION_ID
GENDER_ID
MARITALSTATUS
AGE_APPLIED
FACULTY_ID

Based on Table 1, the attribute BUMISTATUS identifies whether the applicant is a bumiputra or otherwise and it has two distinct values. CITIZEN_ID identifies the nationality of the applicant, which has 246 values representing worldwide countries. LEVEL_OF_STUDY identifies the level of applicant and it has two values indicating Masters or Ph.D CITIZENSHIP_STATUS represents the locality of the applicant, whether the applicant is Malaysian or otherwise.

CHOICE1_APPLIED_ID indicates the program applied by the applicant. PROGRAM_OFFER_ID indicates the program offered by the university. DOMAIN represents the general domain of study with four different values. RELIGION_ID, GENDER, MARITALSTATUS and AGE_APPLIED attributes are self-explanatory. Next, the applicant and program tables were joined together to acquire the attribute FACULTY_ID which, as the name suggests, lists all the faculties available.

2.2 Data Preprocessing

Because data existing in real world are often noisy and most likely contain errors or outliers, pre-processing is imperative to treat any incomplete data such as missing or 'null' values, smoothing the noisy data, and removing or substituting the outliers. Table 2 shows the treatment to missing values in the applicant database.

To prepare for the final data, further pre-processing works were carried out. Since the applicant table contains data on all levels wise, postgraduate applicant was selected. A total of 0.5% from the attribute AGE_APPLIED that contains outliers (225 values from

-1977 to 15 and 60 values greater than 75) was discarded. Similar action was carried out with the attribute CHOICE1_APPLIED that contains values ranging from 1 to 1559. However, only 50 records were found with a value greater than 302. As the consequence, attributes with value greater than 302 were removed, the attribute GENDER and RELIGION are nominal attributes, therefore the missing values were replaced with mode.

Table 2. Treatment of missing values.

Attribute	Type	Replace missing values by
BUMISTATUS	Nominal	Mode
CITIZEN_ID	Ordinal	Mode
LEVEL_OF_STUDY	Nominal	Mode
CHOICE1_APPLIED	Ordinal	Mode
PROGRAM_OFFER	Ordinal	Mode
DOMAIN	Ordinal	Mode
GENDER_ID	Nominal	Mode
MARITALSTATUS_ID	Nominal	Mode
AGE_APPLIED	Ordinal	Average

In this work, the attribute AGE_APPLIED was discretized using the binning method because the attribute values range from 17 to 70. However, all the values sit in different groups within the attribute range so that it can be divided equally. The ultimate advantage is that we were able to analyze AGE_APPLIED with a fewer values (equals to the bins number only) instead of dealing with it individually (all values from 17 to 70). Table 3 shows the sample data after pre-processing.

Table 3. Sample data from the applicant table.

ID	BUMISTATUS	GENDER	RELIGION	AGE_APPLIED	CHOICE1_APPLIED	CITIZEN	DOMAIN	LEVEL_OF_STUDY	MARITALSTATUS	CITIZENSHIP_STATUS	FACULTY
3	2	1	7	23	192	96	2	3	3	6	12
4	2	2	2	27	67	124	2	4	3	6	3
7	2	1	2	28	289	124	2	3	3	6	15
11	2	2	2	27	192	124	2	3	2	6	12
13	2	1	2	23	238	233	2	4	3	6	13
16	2	1	1	26	271	225	2	3	3	6	11

2.3 Cluster Analysis Experiment

To perform the clustering experiment, the Oracle data miner [5] software tool was employed. Oracle data miner is powerful and easy tool, it provides a complete set of functions for cleaning and analyzing the data including efficient data mining algorithms and statistical functions. This tool is also preferred because the pre-processing database operations were run directly from the original database, which is an Oracle database. Figure 1 shows a snapshot of the tool showing the produced model.

The experiment was divided into two parts. In the first part, a comprehensive statistical analysis regarding the applicants' attributes was produced. The analysis covers a general statistic that

Fig. 1. Workflow in the Oracle data miner.

is not focused to any attribute, and multiple statistics carried out with respect to one particular attribute at a time. In the second part, a cluster analysis was performed using two clustering algorithms, which are partitional clustering and hierarchical clustering. Next, the results produced by each algorithm were compared.

From the experiment, it is found that the best number of clusters is $k = 5$, as smaller number of k resulted in smaller number of clusters, which would potentially hide some knowledge while the avoiding the cluster from too detail at the same time.

3. RESULTS AND DISCUSSIONS

3.1 General Statistics

The general statistics performed on the postgraduate UPM applicants revealed the following:

- AGE_APPLIED: The dominant age groups are $21.3 \leq 25.6$, $25.6 \leq 29.9$, $29.9 \leq 34.2$ with values of 35.3%, 23.2% and 17.6% respectively.
- BUMISTATUS: This attribute splits between 54.8% for applicants who are bumiputra and 45.2% for non-bumiputra.
- CITIZENSHIP: This attribute is divided into 62.4% for local and 37.6% for foreigner.
- DOMAIN: This attribute has one outstanding value of 86% which refers to the Science domain.
- GENDER: This simple attribute splits into 52% females and 48% males.
- LEVEL_OF_STUDY: This attribute splits into 79% for master applicants and 21% for Ph.D.
- MARITALSTATUS: 59.1% of the applicants for Masters and Ph.D level are singles and 40.4% are married.
- RELIGION: This attribute shows that 72% of the applicants are Muslim, while 7% are Buddha and the remaining 9% are from other religions.

Table 4. The most applied programs.

Applicants' Choice Statistics		
Most applied program in general		Master of Business Administration
Local	Male	Master of Business Administration
	Female	Master of Education
Foreigners		Master of Science
Age	<21	Master of Science
	[21, 30]	Master of Business Administration
	[30, 47]	Master of Education
	>47	Ph.D
Level of Study	Master	Master of Business Administration
	Ph.D	-No dominant program-

—CHOICE_APPLIED_ID: Table 4 and Table 5 provide statistics about the applicant's applied program.

3.2 Attribute-related Statistics

Statistical analysis with regards to the attribute AGE:

- CITIZENSHIP: In this attribute, there is one prominent group for each value; for locals the prominent group is $(21 \leq 25)$ with a value of 27%, while for foreigners the prominent group is $(25 \leq 29)$ with a value of 11.8%.
- GENDER: A variance between the age groups found in this attribute; as the age group of $(21 \leq 25)$ is dominant for females over males, the age group of $(29 \leq 34)$ and above is dominant for males over females.

Statistical analysis with regards to the attribute BUMI_STATUS:

Table 5. The most applied programs in terms of faculties.

Applicants' Choices Statistics	
Faculty:	Program:
Faculty of Engineering	Master of Science 11,205
Faculty of Educational Studies	Master of Education 10,250
Graduate School of Management	Master of Business Administration 7,064
Faculty of Modern Languages and Communication	Master of Corporate Communication 5,677
Faculty of Computer Science and Information Technology	Master of Computer Science 4,318

- AGE: The youngest age group ($21 \leq 25$) consists of more bumiputra; while other age groups consists of more non-bumiputra.
- CITIZENSHIP: Statistics regarding this attribute shows that 45% of the bumiputra applicants are local; while 17% foreigners.
- GENDER: There are more male and female bumiputra as compared to non-bumiputra.
- LEVEL_OF_STUDY: Statistics for this attribute shows that equal distribution for bumiputra and non-bumiputra as Masters applicants, but more bumiputra Ph.D applicants as compared to non-bumiputra.

Statistical analysis with regards to the attribute CITIZENSHIP:

- AGE: Statistics shows that 27% of the local applicants are in the age range of ($21 \leq 25$), while 8% of the the applicants within the same age range are foreigners. For the age range between 25 and 38, there is equivalent spread between local and foreigner. However, for applicants of older age, they are only local.
- FACULTY: It may be derived from this attribute that both local and foreigners are interested the most in the Faculty of Engineering and Educational Studies, whereby the split is 24.8% local applicants and 14.7% foreigners. The second most popular faculty consists of Faculty of Computer Science and Information Technology as well as Modern Languages and Communication with frequencies of 10.8% and 5.9% for local and foreigners, respectively.
- GENDER: The applicants are composed of 22.9% local males and 25% foreigner males; while 39.6% local females and 12.5% foreigner females.
- LEVEL_OF_STUDY: Statistics for this attribute shows that 55.6% of Master applicants are local while 23.4% are foreigners. As for Ph.D applicants it is 6.8% locals and 14.2% foreigners.

Statistical analysis with regards to the attribute GENDER:

- AGE: Females are generally older than males, but it is most obvious in the age between 21 and 25 there are 23.3% females and only 12.5% males. For the subsequent groups of age, the distribution is equal.
- LEVEL_OF_STUDY: It may be deduced that Master applicants are 35.2% males and 43.8% females, while for Ph.D 12.7% of the applicants males and 8.3% are females.

3.3 Cluster Analysis

Figure 2 shows the cluster analysis by applying the *K*-means clustering algorithm. The resulting *K*-means cluster group the applicants into the following categories. The first and dominant group is the group of single local females who are bumiputra their age ranges between 21 to 30 years. This group forms a percentage of 30% from the total applicants. The second is the group of single applicants who are non-bumiputra, age between 25 to 47 years with

a percentage of 26%. Next comes a unique group which consists of a group of all Ph.D applicants who are non-bumiputra, foreigners and their age are between 25 to 47 years old. This group composed around 9% from the entire data. The last two clusters are actually concerning married applicants; local bumiputra between the age of 25 to 47 years (21%) and the other one is for non-bumiputra foreigners, which constitutes 9% from the total applicants.

Fig. 2. Cluster produced by *K*-Means partitional clustering.

Figure 3 shows the cluster analysis by applying the *O*-cluster clustering algorithm. Note that the resulting *O*-cluster are totally different, in fact, while the first algorithm concentrated on residence and gender attributes, the *O*-cluster discards these attributes and focus mainly on the faculty and age attributes.

The first cluster comes very accurate, containing all the applicants which corresponds to the management domain and belong to the Graduate School of Management, while their age ranges between 21 to 42 years (15%). The next group specifies all the Masters applicants who belong to the Faculty of Modern Languages and Communication as well as the Faculty of Computer Science and Information Technology are aged between 21 to 42 years (22%).

The third cluster reveals the group of married applicants whose age are between 21 and 47 years and belong to the Faculty of Engineering, Science and Educational Studies. This group constitutes 25% from the total applicants. Finally, the the last two

groups have two common features; both of these groups are single and their age are between 21 to 34 years old. The discrimination comes in the first group as applicants in this group are local and belong to the Faculty of Science, Economics and Management, and Forestry (7%), while the second group belong to different variety of faculties regardless the citizenship status. These faculties include the Faculty of Engineering, Educational Study, and Agriculture (29%).

Fig. 3. Cluster produced by O-Cluster hierarchical clustering.

4. CONCLUSION

The paper presented statistical and cluster analysis on postgraduate application database in Universiti Putra Malaysia (UPM) for better marketing and decision making. The research is hoped to shed insights in how data mining could be used in understanding the postgraduate education market. In the future, the plan is to integrate the analysis into executive information system for strategic planning at the university level.

5. REFERENCES

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