

Academic preference based on students' personality analysis through *k*-means clustering

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Article history

Received 14 May 2019
 Revised 21 September 2019
 Accepted 5 January 2020
 Published Online 15 June 2020

Abstract

It is believed that the education quality increases in line with the knowledge and understanding of students' personality. The theory and techniques associated with measurement of skills, abilities, attitudes and psychological traits are studied under the field of psychometrics. The students' psychometric scores and their academic programme of choice from a local university in Malaysia are analysed using *k*-means. It is found that there are distinctive clusters to differentiate the students' personality traits and the differences can influence them in choosing certain programmes. Hence, the results are useful to determine the suitable methods to increase the students' academic performance.

Keywords: psychometric test, personality analysis, academic preference, *k*-means clustering

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INTRODUCTION

The decision in choosing an academic programme to be pursued in university or other tertiary institutions is important to be made by young adults, this life decision will significantly affect their future. Since higher education and high retention rates are economically desirable and offer benefit to both individuals and society (Bloom *et al.*, 2007), society has an interest in helping young adults and students to find the right academic programme and major for them to undertake. Hence, academic advising becomes a priority in societies and research, regarding this matter to become a recurrent focus of interest (Frost & Brown-Wheeler, 2003).

It is believed that there may be an optimal "fit" between student and academic programme or major based on the student's personality (Vedel, 2016). This idea has been brought forth by Holland (1997) and the relation between academic majors and various personality taxonomies had been investigated as early as 1967 by Goldschmid (1967). Various studies have been conducted over the years to determine if different types of students are more prone to different academic majors (Kaufman *et al.*, 2013; Lievens *et al.*, 2002; Lounsbury *et al.*, 2009; Rubinstein, 2005). However, not many of these researches are done involving students at the very beginning of their first academic year (Vedel *et al.*, 2015) which can determine that the differences between academic majors are pre-existing and not due to their surroundings and associations during their academic studies. Furthermore, most of the studies use correlation, hypothesis testing or ANOVA to look into the relationship between students' personality traits and academic majors, difference in between genders as well as between measures of personality traits. These methods are looked into

the students' personality traits without placing academic programmes with students sharing similar traits in a group.

If the notion that some academic majors are more suitable for a group of students with certain desirable personality traits is true, this will be useful for academic counselling and practice. For example, educators can customize their teaching methods according to the types of students for optimal knowledge transfer. The knowledge regarding the suitability of academic programmes according to types of students will assist students to apply for the programmes that they can benefit from and excel so that they can graduate with flying colours.

The study on theories and techniques to measure skills, abilities, attitudes and other psychological traits falls under the field of psychometrics. In this study, psychometric tests are distributed among students who had just enrolled in a local university in Malaysia and cluster analysis is performed based on the personality traits determined by their psychometric scores. Then, the relationship between the academic programmes chosen by them and their personality traits are looked into to understand the difference in terms of academic preference based on the students' personalities. The method of clustering is used in this study to investigate these relationships since it can consider the fact that students with similar traits can choose a few academic programmes that they prefer above others and thus, grouping them into one cluster.

DATA

The data consists of psychometric scores and academic programmes of 3167 students that enrolled in a local university in Malaysia. The psychometric test is done at the very beginning of their

first academic year to ensure that the personality traits based on the psychometric scores are pre-existing and are not due to socializations with the same academic circles. The students under study come from 70 different academic programmes inclusive of both science and art streams.

The data is obtained from Tell N Search, a talent management company in Malaysia. The data consists of scores from some common psychometric models which are the sixteen personality traits, eight primary skill sets, global big five factors and Holland code.

PSYCHOMETRIC MODELS

Sixteen personality traits

Cattell *et al.* isolated 16 personality factors which they derived and measured through a psychometric test called 16PF (Cattell *et al.*, 1970). These 16 personality traits are found by extensive use of factorial analysis method (Córdoba & Jaramillo, 2012). The 16 personalities can be grouped into four categories; interaction with others, thinking style, consistency, and emotional and personality. These personalities are described as in Table 1 (Tell N Search, 2017).

The 16 personality traits are measured in decatype, which means that each individual will has a score of 1 to 10 for each trait. The scores for each trait are divided into three levels; low (1 – 4), normal or average (5 – 6), and high (7 – 10).

Table 1 Sixteen personality traits.

Category	Traits	Descriptions
Interaction with others	Warmth	Indicates friendliness and willingness to participate in activities with others.
	Self-reliance	Identifies an individual is either self-sufficient or group-oriented.
	Privateness	Identifies an individual is either self-revealing or non-disclosing.
	Reasoning	Indicates cognitive ability and intellect.
	Social boldness	Identifies an individual is either timid or out-going.
	Dominance	Identifies an individual is either submissive or assertive.
	Vigilance	Identifies an individual is either trusting or suspicious of others.
Thinking style	Abstractness	Identifies an individual is either practical or imaginative.
	Sensitivity	Indicates compassion and sympathetic towards others.
	Openness to change	Indicates flexibility towards change or attachment to familiarity.
	Liveliness	Identifies an individual is either serious or carefree.
Consistency	Rule consciousness	Indicates attitude towards authority and obedience.
	Perfectionism	Indicates self-discipline and precision.
Emotional & personality	Emotional stability	Identifies an individual is either temperamental or calm.
	Apprehension	Identifies an individual is either self-assured or insecure.
	Tension	Identifies an individual is either laid back or tense.

Eight primary skill sets

The sixteen personality traits obtained from the 16PF test are also able to form eight primary skill sets where two traits are combined to identify if a person has a skill set. The eight skill sets and the traits that make up the skill sets are shown in Table 2 (Tell N Search, 2017). The scores for these skill sets are of the binary type where it takes on values of 1 (possess said skill set) or 0 (does not possess said skill set).

Table 2 Eight primary skill sets.

Skills	Traits
Social	Tension, Liveliness
Communication	Emotional stability, Warmth
Information management	Sensitivity, Privateness
Ethics	Rule consciousness, Perfectionism
Critical thinking	Reasoning, Vigilance
Leadership	Dominance, Self-reliance
Entrepreneurship	Apprehension, Social boldness
Creativity	Abstractness, Openness to change

Global big five factor

The 16 personality traits can also be used to derive the global big five factors model. The big five factors model has been useful in helping scientists to organize and standardize knowledge over the past few decades (Saucier & Srivastava, 2015). The global big five factors model used in this study is as described in Table 3 (Tell N Search, 2017). The scoring used for the five factors are similar to the one used in the 16PF model. The scores are between 1 and 10 with three levels; low (1 – 4), normal (5 – 6), and high (7 – 10).

Table 3 Global big five factors.

Factors	Traits	Descriptions
Extraversion	Warmth, Liveliness, Social boldness, Privateness, Self-reliance	Introverted or Extraverted
Anxiety	Emotional stability, Vigilance, Apprehension, Tension	Imperturbable or Perturbable
Self-control	Liveliness, Rule consciousness, Abstractness, Perfectionism	Receptive or Resolute
Independence	Dominance, Social boldness, Vigilance, Openness to change	Selfless or Willful
Tough mindedness	Warmth, Sensitivity, Abstractness, Perfectionism	Unrestrained or Self-controlled

Holland code

The last model used in this study is the Holland code which is based on the assumption that the vocational interests of most people can be characterized by a combination of six types; Realistic, Investigative, Artistic, Social, Enterprising and Conventional (RIASEC) (Jaensch *et al.*, 2016). The Holland code has changed the field of counseling and career psychology (Nauta, 2010) since its introduction in 1973 (Holland, 1973).

The scores for all six types of Holland code for an individual are ranked from highest to lowest. The highest score, which is ranked 1, is considered as the most optimal type to characterize the person and so on. This personal interest code can be matched to the most suitable career that fits his or her interests and abilities (Jaensch *et al.*, 2016). The descriptions for the types in Holland code are given in Table 4 (Tell N Search, 2017).

Table 4 Types in Holland code.

Types	Descriptions
Realistic (Doer)	Interest in orderly mechanical, manual or outdoor activities.
Investigative (Thinker)	Interest in problem solving and conceptual thinking.
Artistic (Creator)	Interest in graphic, musical, literary and performing arts.
Social (Helper)	Interest in helping and caring for others.
Enterprising (Persuader)	Interest in persuading and leading people.
Conventional (Organizer)	Interest in managing projects orderly and efficiently.

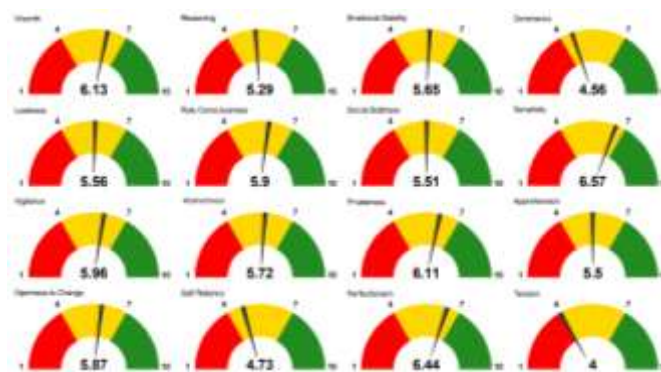


Fig. 1 Average scores of the sixteen personality traits for all respondents.

THE METHOD OF k-MEANS CLUSTERING

Cluster analysis is a common statistical data analysis method used to group a set of observations with similar characteristics into one group and those with different characteristics into different groups (Swathi & Govardhan, 2009). The *k*-means clustering method is a common and popular algorithm in cluster analysis since it is easy to be implemented and simple to understand (Slamet et al., 2016). Basically, the method of *k*-means is performed to cluster nearby objects into *k* number of centroids with the coordinates of each centroid, which is the mean of the coordinates of objects in each of the *k* clusters (Park & Jun, 2009). These centroids are deemed as the centers of the clusters.

The *k*-means clustering method is used to cluster the psychometric scores of the sixteen personality traits with respect to the academic programmes of the respondents. With this, the personality traits for students of various academic programmes can be grouped together and the traits for each group will be investigated further.

The first step in performing the *k*-means clustering is to find the average scores of each personality trait for all academic programmes. Hence, each academic programme will possess a set of 16 average values for all 16 personality traits. Then, the number of clusters, *k*, that is suitable for the analysis is determined. Each of these clusters is randomly assigned with a centroid from the data set, i.e. a set of 16 average values for the 16 personality traits of a randomly chosen academic programme. The Euclidean distance between each academic programme and all the *k* centroids is then calculated. For an academic programme *X* with an academic programme *Y* as a centroid, the Euclidean distance between *X* and *Y* is obtained as follows:

$$d(X, Y) = \sqrt{\sum_{p=1}^{16} (x_p - y_p)^2}$$

with x_p and y_p are the average of personality trait *p* in academic programmes *X* and *Y*, respectively. Each academic programme is then put into a group with a centroid that gives the minimum distance value between the average scores of the academic programme and the average scores of the centroid. For each newly formed group, the mean value for all the 16 personality traits in the group is calculated and taken as the new centroid for the group. Then, the Euclidean distance for all academic programmes and the newly found centroids is calculated and each academic programme is grouped to the nearest centroid. This process is repeated until no change is found in the members of each group and in the values of the centroids.

RESULTS AND DISCUSSION

The psychometric scores of 3167 students from 70 academic programmes are used in this study. The average scores of all 16 personality traits for all respondents are shown in Fig. 1 while the average scores according to gender are given in Table 5.

Based on Fig. 1, the average scores for all personality traits of respondents show normality and there is no extreme personality since all of the average values are neither lower than 4 nor higher than 7. However, the personality trait Tension is already at the border of the lower extreme with an average score of 4.00. If these respondents are used to represent Malaysian university students or youths, then the low Tension level indicates that Malaysian youths are easy-going and laid back. The personality with the second lowest average score is Dominance, indicating that the respondents are generally modest and cooperative. They prefer to avoid conflict and accommodate others' wishes. On the other hand, there are some traits that almost reach the high extreme border such as Sensitivity and Perfectionism with average scores of 6.57 and 6.44, respectively. A somewhat high score of Sensitivity shows that Malaysian university students are cultured, emotionally sensitive and vulnerable. However, they tend to be empathetic and sympathetic towards others. Meanwhile, a high Perfectionism score implies that Malaysian students are self-disciplined and goal-oriented but less flexible.

Table 5 Average scores of the sixteen personality traits according to gender.

Traits	Male	Female
Warmth	5.92	6.22
Self-reliance	4.72	4.74
Privateness	5.84	6.22
Reasoning	5.48	5.21
Social boldness	5.57	5.48
Dominance	4.68	4.50
Vigilance	6.08	5.91
Abstractness	5.91	5.63
Sensitivity	5.61	6.99
Openness to change	5.93	5.85
Liveliness	5.65	5.52
Rule consciousness	5.68	6.00
Perfectionism	6.35	6.48
Emotional stability	5.65	5.65
Apprehension	5.36	5.57
Tension	3.86	4.07

Based on **Table 5**, the average scores for male and female students do not exhibit a significant difference, especially for traits like Self-reliance, Social boldness, Dominance, Vigilance, Openness to change, Liveliness and Emotional stability. Male students show considerably higher average scores for Reasoning and Abstractness compared to female students. This implies that, on average, Malaysian boys are more capable to solve verbal and numerical problems as well as more

imaginative and idea-oriented. Meanwhile, female students show considerably higher average scores for traits such as Warmth, Privateness, Sensitivity, Rule consciousness, Apprehension and Tension. This indicates that Malaysian girls are more caring, guarded, empathetic, dutiful, anxious and impatient compared to Malaysian boys.

The average scores for all 16 personality traits are calculated for all 70 programmes. These average scores are used for *k*-means clustering analysis. In this study, the number of clusters to be formed is chosen as six, i.e. *k* = 6, since it is of interest to find out if the six clusters obtained are equivalent to the six types of Holland code.

The six clusters obtained from the *k*-means clustering are as shown in Table 6. It is found that each cluster has a somewhat distinct similarity between academic programmes in the same cluster and quite distinct differences between academic programmes in different clusters. Hence, this shows that personality traits can influence individual academic preference.

Table 6 Six clusters obtained through *k*-means clustering.

Cluster	Academic Programmes
1	Political Science, Malay Literature Studies, Geography, Developmental Science, History, Malay Language Studies, Economy, Theology and Philosophy, Syariah, Arabic Studies and Islamic Civilization, Da'wah and Leadership Studies, Al-Quran and Al-Sunnah Studies, Nutrition Science, Environmental Health, Nursing, Business Management, Biology, Sports and Recreation, Special Education
2	Pharmacy, Dietetic, Food Science, Environmental Science, Biochemistry, Genetic, Biotechnology with Management
3	Dentistry, Medicine, Optometry, Audiology, Diagnostic Imaging and Radiotherapy, Physiotherapy, Occupational Therapy, Actuarial Science, Food Science with Business Management
4	Anthropology and Sociology, Psychology, Social Work, Media Communication, English Language Studies, Linguistic, Law, Speech Therapy, TESL
5	Computer Science, Information Technology, Information System Development, Multimedia System Development, Entrepreneurship and Innovation, Architecture, Biomedicine, Forensic Science, Marine Science, Mathematics, Statistics, Physics, Chemistry, Geology, Nuclear Science, Material Science, Chemical Technology, Oleochemicals, Microbiology, Bioinformatics, Plant Biotechnology
6	Civil Engineering, Electrical Engineering, Chemical Engineering, Mechanical Engineering, Electronic Engineering

From Table 6, it is shown that Cluster 1 consists of mostly art majors. Although there are also science majors such as Political Science, Nutrition Science and Biology, these are also academic majors that require a lot of reading and memorization similar to art stream's academic programmes. Meanwhile, most of the academic programmes in Cluster 2 can be linked to Chemistry. On the other hand, Cluster 3 is mostly made up of academic under Medical or Health Science field. Only two academic programmes which are of different nature are Actuarial Science and Food Science with Business Management. However, Actuarial Science is one of the top programmes in Malaysia along with Medicine and Dentistry. Cluster 4 consists of academic majors that mostly deals with human and communication. Cluster 5 is mostly made up of Science and Technology majors except Architecture and Entrepreneurship and Innovation. Finally, Cluster 6 is dominated by engineering programmes. Interestingly, most academic programmes from the same faculty are grouped together in the same cluster. This means that there is a difference in personality traits for different types

of academic majors. Table 7 shows the average scores while Fig. 2 provides the boxplots for the distribution of the sixteen personality traits for all six clusters. Fig. 3 shows the percentages of students in each level of the 16 personality traits in all six clusters.

Table 7 Average scores of the sixteen personality traits for all six clusters.

Traits	Cluster					
	1	2	3	4	5	6
Warmth	6.49	5.60	6.60	7.08	5.53	5.10
Self-reliance	4.58	5.09	4.46	4.64	5.05	4.62
Privateness	6.19	5.99	5.71	6.12	6.26	5.86
Reasoning	4.94	5.66	6.14	4.99	5.39	5.73
Social boldness	5.47	5.25	5.99	5.71	5.33	5.61
Dominance	4.46	4.44	4.59	4.69	4.53	4.88
Vigilance	5.88	5.89	5.65	6.23	6.05	6.04
Abstractness	5.64	5.85	5.31	5.88	5.84	5.78
Sensitivity	6.75	7.00	6.55	7.63	6.33	4.93
Openness to change	5.61	5.84	6.26	6.14	5.92	6.12
Liveliness	5.47	5.47	5.63	5.82	5.48	5.75
Rule consciousness	6.21	5.56	5.88	5.82	5.74	5.52
Perfectionism	6.61	6.22	6.37	6.37	6.33	6.37
Emotional stability	5.67	5.42	6.10	5.64	5.51	5.66
Apprehension	5.53	5.69	5.33	5.53	5.52	5.35
Tension	3.96	4.31	3.67	4.14	4.05	3.96

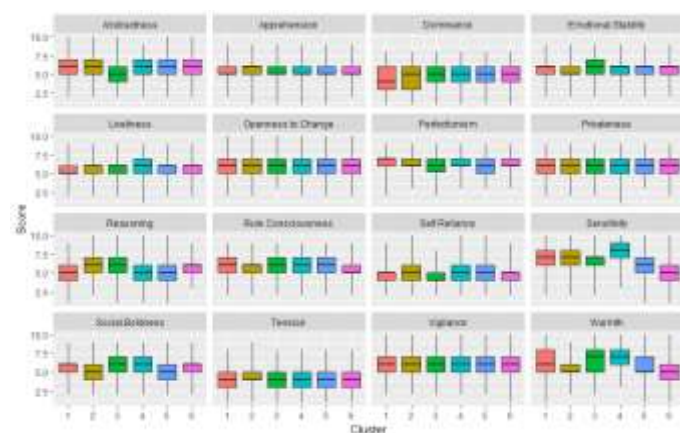


Fig. 2 Distributions of the sixteen personality traits' scores for six clusters.

Based on Table 7, Fig. 2 and Fig. 3, the distributions for all 16 traits are almost similar between the six clusters. However, there are some traits that certain clusters differ from the rest. For example, Cluster 6 which consists of engineering students has the lowest mean scores for Warmth and Sensitivity, as well as the highest percentages of students with low levels of Warmth and Sensitivity. Cluster 6 also has the lowest average of Rule Consciousness. Meanwhile, Cluster 3 with mostly of Medical and Health Science majors, has the lowest average for Abstractness and the smallest percentage of students with high level of Abstractness. The same pattern is observed for Self-reliance while the opposite is true for Emotional stability. Cluster 4 which grouped academic programmes that deal with human and communication shows that, on average, it has the highest scores for Warmth, Sensitivity and Liveliness. This is also illustrated in Fig. 3 where the percentages of students with high level of the three traits are higher in Cluster 4 compared to other clusters. Meanwhile, Cluster 2 shows the highest mean and the biggest value for percentage of high level of Apprehension and Tension. This means that the academic programmes

in Cluster 2 have students who are more insecure and easily tense compared to other programmes.

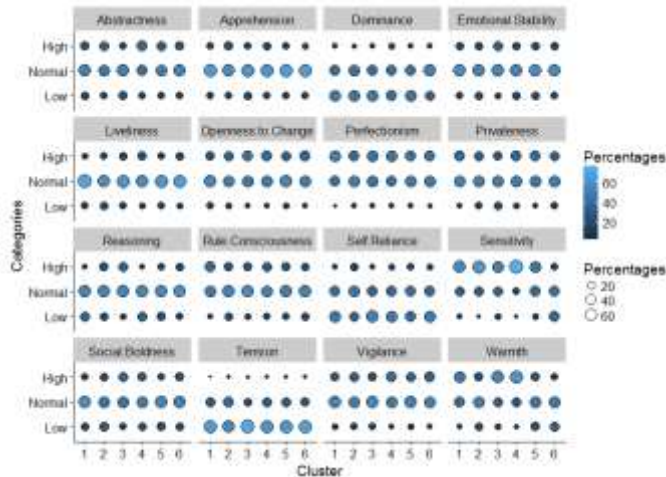


Fig. 3 Percentages of students for three levels of the sixteen personality traits in six clusters.

Fig. 4 shows the percentages of students with or without the eight primary skill sets in the six clusters. Fig. 4 indicates that a majority of Malaysian university students are lacking most of the primary skill sets, especially Creativity, Critical Thinking, Entrepreneurship, Information Management, Leadership and Social Skills, which is unfortunate for university students since these skills are crucial for success in future careers. Equal percentages of students can be seen with and without Ethics for all six clusters. Both Cluster 3 and Cluster 4 show higher percentages of students with Communication skills compared to other clusters. This is desirable since both clusters involve with academic majors that lead to interaction-oriented careers.

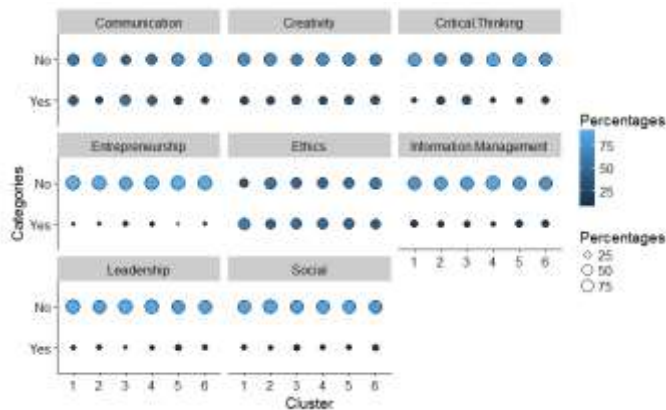


Fig. 4 Percentages of students with or without the eight primary skill sets in the six clusters.

Meanwhile, the average scores for the Global Big Five Factors model of all six clusters are given in Table 8, whereas the plots for distributions are given in Fig. 5 and the percentages of students for the three levels of each factor are shown in Fig. 6.

Based on Table 8, Fig. 5 and Fig. 6, Cluster 3 has lower Anxiety level than the other clusters. This is good for individuals in the medical line because they need to be calm to administer the best treatments for patients. Cluster 3 and Cluster 4 show higher scores and more percentages of students with high level Extraversion factor, which indicates that students in both clusters are more socially engaged compared to other clusters. This is in line with the fact that both clusters have more students with Communication skills. Meanwhile, Cluster 1 shows a higher average score for Self Control, indicating that students in the cluster are more resolute. For the factor Tough Mindedness, Cluster 4 shows a lower average score and a bigger percentage of students with low level values compared to other clusters. This means

that respondents in this cluster are more impulsive. In contrast, Cluster 6 shows higher average score and percentage of students with high level of Tough Mindedness compared to other clusters.

Table 8 Average scores of the global big five factors for all six clusters.

Traits	Cluster					
	1	2	3	4	5	6
Extraversion	5.85	5.45	6.22	6.18	5.38	5.63
Anxiety	4.94	5.25	4.50	5.13	5.09	4.92
Self-control	6.19	5.71	6.03	5.80	5.83	5.72
Independence	4.98	4.97	5.36	5.42	5.10	5.45
Tough Mindedness	4.58	4.45	4.43	3.68	4.77	5.47

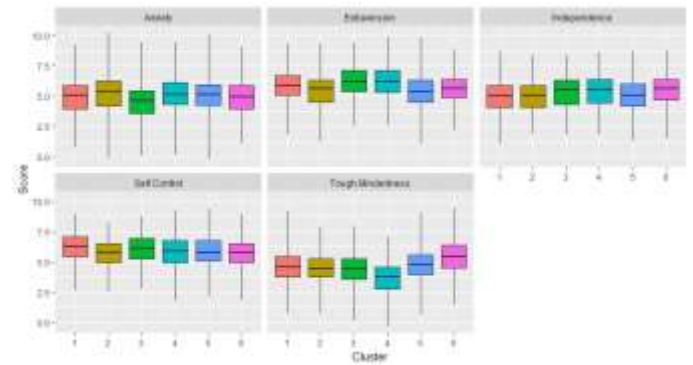


Fig. 5 Distributions of the global big five factors scores for six clusters.

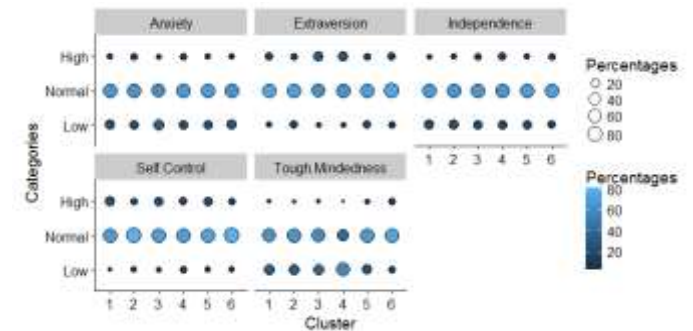


Fig. 6 Percentages of students for three levels of the global big five factors in six clusters.

Finally, the six clusters are compared to the six types of Holland code. The percentages of students that ranked 1 to 6 for all six clusters are shown in Fig. 7. From this study, there is no indication of which type of Holland code is dominant for a cluster. Generally, Malaysian university students are ranked higher for Social, especially Cluster 3 and Cluster 4. This is a desirable result since it is believed that individuals with dominant Social type are regarded to have an interest in caring for others. On the other hand, engineering students in Cluster 6 show the lowest percentage of students with ranked 1 in Social. However, Cluster 6 has the highest percentage of students that ranked 1 in Realistic since they are more prone to mechanical and outdoor activities. In contrast, Cluster 4 shows the lowest percentage of rank 1 and the highest percentage of rank 6 for Realistic. This is to be expected since Cluster 4 is consisted with students with academic majors that deal more with human rather than objects and machines. Cluster 5 and Cluster 6 also show higher ranks for Investigative which is suitable for academic programmes that involve problem solving and conceptual thinking such as science and mathematics. Surprisingly, although Cluster 1 consists of mostly art stream majors, the respondents in this cluster are mostly ranked 6 for Artistic. However, Cluster 1 and Cluster 2 show higher percentages of students with rank 1 for Conventional. It is unfortunate that Cluster 3 which includes Actuarial Science has the

lowest percentage of students ranked 1 for Conventional since being organized is good for careers with efficient procedures such as actuarist. Overall, Malaysian students, as a whole, ranked low for Enterprising which shows that Malaysian youths lack in persuasion characteristics.

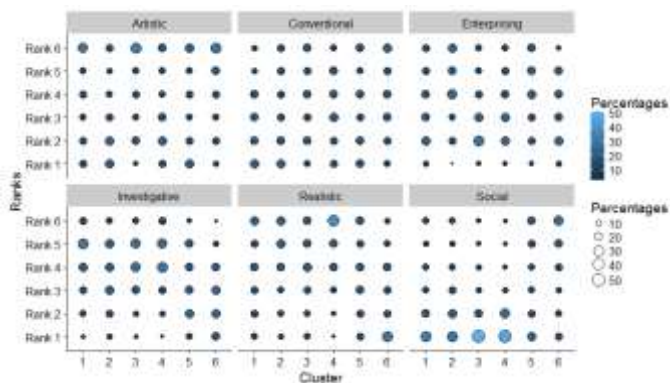


Fig. 7 Percentages of students ranked 1 to 6 for Holland codes in six clusters.

CONCLUSION

The effort of finding an optimal “fit” between students and academic programmes or majors based on their personalities is believed to be able to help young adults to find the right academic programme and major for them to undertake. In this study, the psychometric scores and academic programmes of students enrolled in a local university in Malaysia are investigated to explore the possibility that personality traits play a role in individual academic preference. Based on the cluster analysis, it is found that there are distinctive clusters that differentiate students based on personality traits and the differences affect their inclination in choosing academic programmes. The clusters obtained have grouped most academic programmes under the same faculty into the same cluster. This proves that there are some personality traits which are more suitable for some academic majors. Common psychometric models which are the sixteen personality traits, eight primary skill sets, global big five factors and Holland code are looked into for all the six clusters. In general, Malaysian university students do not portray any extreme behaviours. However, they are lacking in terms of primary skills. Obvious differences in personalities are seen for students with academic programmes related to engineering, medical and health science, as well as academic majors that dealing with human.

ACKNOWLEDGEMENT

The authors would like to express utmost gratitude to Universiti Kebangsaan Malaysia (UKM) for the allocation of research grant, KRA-2017-019 and GGPM-2015-026, and infrastructures used in this study. The authors would also like to thank Tell N Search for providing the data used in this study.

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