Journal of Engineering and Applied Sciences 12 (3): 705-714, 2017
ISSN: 1816-949X
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Multi-Criteria Decision Making (MCDM) for Bachelor of Aircraft Engineering Technology (Avionic) Final Year Students in Project Management Course: AHP Method for Career Selection

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Abstract: Career selection for many especially for students is a crucial process. Previous studies show that job seeker chose career either based on income, academic qualification or the benefit that may gain. This study was conducted among final year BAET students taking project management course at Universiti Kuala Lumpur Malaysian Institute of Aviation Technology (UniKL MIAT) to identify MCDM used by students in selecting a career. Students are distributed into small groups (between four to five members). Contrary to other earlier studies-whereby a list of criteria and scale range used for criteria are given, this study allowed students to figure out the list of criteria and scale range to be used for comparison based on their discussion within their own group. Students were also allowed to set their own range of scale for comparing the criteria and alternatives. The criteria were then analyzed using Analytical Hierarchy Process (AHP) method to identify the chosen career by students. The highest score among each group was then taken to check on its consistencies to ensure the alignment of the scoring with the objective of AHP method which is to provide objective and minimize subjective decision criteria. Apart from understanding the MCDM used by students in selecting a career, AHP method exercise in the class as part of the tutorial for project management course has helped students to understand the decision-making process using AHP.

Key words: Analytical Hierarchy Process (AHP), Multi-Criteria Decision Making (MCDM), group career selection

INTRODUCTION

Career selection is a very complex and comprehensive process especially for fresh graduate who are having minimum related working experience. To select a career, students require criteria for selection as a basis or guideline for them to make the best decision. Adiguzel and Cetin (2010) states that factors in career selection are important to direct future depending upon the factors selected. Determining criteria for job selection is not only confined to factors such as income and future prospect, however, to make a better decision, the use of multiple criteria in selecting the suitable career is essential.

AHP method used in this study to analyze job preference among BAET (Avionics) students taking project management course based on the criteria listed by the students themselves. The aim of this study is to expose students with AHP method; to assist them in the selection of career; objectively and to analyze the MCDM used by students for career selection. The study is conducted as part of the class tutorial whereby students are explained with the approach of the method at the beginning of the session. The experiment has been conducted during the 'project selection' topic lecture and tutorial class. During the lecture, students were exposed to multiple approaches to selecting a project such as simple scoring, simplified scoring model, AHP, profile model and financial model. The vacancies posted publicly on the internet by Maintenance, Repair and Overhaul (MRO) companies for product/process engineer, project engineer and quality assurance executive is used. A sample of job posting (which relates to their field of study) has been selected to be used in the class as a case study.

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Literature review: AHP method is one of the methods used in decision making that helps to capture subjective and objective aspects of a decision. On top of that AHP incorporates consistency check on decision maker's evaluations, therefore minimizing the biases in the decision-making process (Mammadova and Jabrayilova, 2014). In many studies, several approaches have been combined AHP with another method such as Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) and fuzzy method to analyze the job selection criteria by respondents. Notably, AHP method was used by many researchers studying on decision making as shown in previous decision making related studies by Alhuraish *et al*. (2016), Chuu (2014), Haas and Meixner (2009), Moghimi and Zheng (2009).

AHP method has been used widely as a process improvement tools for achieving the objective by assessing multiple criteria. Other studies by Lokare and Jadhav (2016) are integrating AHP with another method, i.e., TOPSIS to evaluate the best course selection after Higher Secondary Certificate (HSC), (Torfi and Rashidi, 2011) for the selection of project managers in construction firms and (Mammadova and Jabrayilova, 2014) for the personal selection of vacancy that combined TOPSIS for evaluation and regulating alternatives. The process of AHP tutorial conducted in the class is guided by the AHP tutorial notes by Haas and Meixner (2005).

This study is aligned with a study done by Haas and Meixner (2005) whereby it has been conducted to students and using the potential job vacancies in the related field as a guide. However, the scope area of this study slightly differs with the approach taken by Haas and Meixner (2005) and Davvodi (2009) as students are needed to list their own criteria based on the three listed job vacancies as a guide. Studies by both Haas and Meixner (2005) and Davvodi (2009) have given students the list of criteria to guide them in career selection process (Table 1 in Appendix A).

MATERIALS AND METHODS

The flowchart in Appendix B shows Fig. 1, the process of this study which has led to the career selected by students. Students have been asked to list out criteria to analyze their selection of career once they have formed their small group discussion. There are two classes involved in this study which is namely as 7BAV (six groups) and 7×BAV (two groups). Six groups from 7BAV class were asked to set eight criteria while two groups in 7×BAV were asked to set five criteria. Each group consists of four or five members and they have selected their own team members for the whole classes for group projects and tutorial exercise. Multi-criteria in career selection are important (Siew *et al*., 2015). However, this study has further expanded the evaluation by dividing students into smaller groups, allow them to choose their own criteria and at the end, observation is made for the job that they have selected.

In total, there are 35 students from two classes participated in the tutorial: 7BAV class (25 students) and 7×BAV class (ten students) taking project management course in July 2016 semester. Students in the 7BAV class were divided into six groups while students in 7×BAV were divided into two groups. Students are in their final year of eight-semester degree is considered as the most suitable sampling for this study. As final year students, they are very close to the career industry. Random questions asked in the class discovered that majority of them does not have formal working experience (in the industry) related to their field of study, neither of them have working experience before or they have experienced worked before but within a shorter period (part time). After completing their study for eight semesters, final year students of BAET (Avionics) will be doing their On the Job Training (OJT) or industrial attachment with the industry for six months before finally graduating.

Use of AHP method is hoped to help students in exposing them subjective and objective aspects of the decision-making process. The use of AHP and MCDM method of this study been conducted in project management class as one of the tutorial exercises. Job vacancies advertised on the internet has been used as a case study for student's career selection. The company (namely as company XYZ) is an MRO company which is related to the student's field of study. Each group has been asked to list criteria to be used in selecting a career and the ranking scale (for comparing the criteria importance).

In this study, each group is required to select a career using AHP method from the three vacancies advertised which are project engineer, product or process engineer and quality assurance executive. The goal of the study is similar for all groups, the purpose is to understand the job selected by students by using AHP method. The process of summarizing the job selection by using MCDM and assessed by multiple groups are depicted in Fig. 2 in Appendix C. Use of AHP method consists of four basic steps (Alexander, 2012) which are:

- Develop the hierarchy tree that consists of alternatives and criteria
- Determine the priority of each of criteria using the table and the ranking scale proposed by Saaty (2008)
- However, in this study, students are given the opportunity to use their own ranking scale

- Matrix calculations or pairwise comparisons are performed after prioritization of criteria and alternatives are performed
- Criteria and alternatives are performed until the total value of the eigenvector is equals to 1.0 which is the main objective of any selection process using AHP

Students are given with the job description of three job vacancies advertised on the internet which related to their field of study. All eight groups of students are using the same job vacancies as the goal of their tutorial exercise. Figure 3 in Appendix C shows the process of AHP methods applied by each group. Each group required to set their criteria as needed by the method.

Step 1 (Elaboration of AHP): Students have been elaborated with the options for selecting a career using the selection tools listed in the introduction section above. To set the standard objectives among groups, job vacancies advertised on the internet from the company is used as the goal for this AHP analysis. Students were given several minutes to read the job description and requirements of the job and the company. They were informed that the purpose of the exercise is for them to choose the job by using AHP model. AHP was chosen instead of other method of selection as it is widely used and at the same time AHP can be considered as a method that can translate qualitative and quantitative evaluations made by decision maker (Saaty, 1980).

Step 2 (Setting of criteria): Once students have set the objectives and understand briefly with the AHP process, they were asked to identify eight criteria (for 7BAV class) and five criteria (in 7xBAV class) to be used by their group in the exercise. The list of criteria was based on their group preferences and discussion in selecting a career. The number of criteria chosen among groups is purposely made different. The criteria chosen by students later were classified by the researchers into four groups based on the factor that is affecting the decision by students.

List of criteria chosen by students during the tutorial was classified. Figure 4 in Appendix C shows that criteria used by students be classified into four areas which are Company Factors (CF), Job Factors (JF), Personal Factors (PF) and Environmental Factors (EF). As AHP consists of both qualitative and quantitative approach, the setting of criteria within the group is purely based on qualitative analysis whereby the researchers own observation shows that majority of the students were using simple voting method (by raising their hands) to choose eight or five criteria for their group. The summary result of factors selected by all groups is shown and discussed in the result section.

Step 3 (Setting of ranking scales): In step 3, students were needed to give scoring; comparing each of the criteria and alternatives-based on the ranking scale that they have defined for their own group and performed Pairwise Comparison subsequently. When comparing criteria using the ranking scale, students were comparing two criteria (in pair) at a time and the score was put to each criterion (using the ranking scale). In other studies, authors were observed using the set ranking scale developed by Saaty (1980). After the scoring process, students calculated the Eigenvector Values (EV) using the pairwise comparison method or matrices calculation. Pairwise comparison method is designed to provide a fair comparison to the selection of the goal or objective which is called as condorcet criterion.

Similar to the set of criteria, students were also asked to set their own ranking scale to compare the criteria for selection. The range of scale used by students was different between groups. To deploy a standard assessment, all groups are required to set the highest number (as highly important) while the lowest number as least important. The summary of ranking scale set by students are summarized in Figure 5 in Appendix C. The purpose of defining ranking scale is to assess the importance of each criterion. Each group is using a different range of ranking scale. Regardless of a scale range they defined, the highest scale or numbers indicate the greatest value. The same approach is used by Engineering in reference to Saaty (1980). However, intermediate ratings in this study were not performed. Students will rank the criteria based on the scale that they have defined earlier.

During the exercise, it was observed that some of the groups were calculating the pairwise comparison using manual calculation while some are resorted to free online calculators such as https://matrixcalc.org/en/,Google store apps (matrix calculator alexander skokov) or https://matrix.reshish.com/multiplication.php. Matrix multiplication can also be calculated using Microsoft Excel software, i.e., MMULT (range1, 2) function.

Step 4 (Result analysis of each group): After performing the exercise from step 1 until step 3, result from each group was analyzed and discussed in step 4. Majority of the group took between 90 min to 2 h to complete the whole tutorial. The observation of the result was emphasizing on the criteria categories chosen by

students, categories chosen by a different class, career selected by students and the consistency ratio of the result performed.

Figure 6 in Appendix C shows that the highest criteria scoring is discipline criteria. After the whole AHP process, four groups from the eight groups have selected project engineer as a career of choice while the other two groups have fairly selected either product/process engineer or quality assurance executive. Meanwhile, major criteria that are considered important by all groups are salary or income received (paycheck/wages) for considering a career.

In total, there are 58 criteria used by all groups in selecting a career. CF have shown the most criteria selected by students in selecting a career (with 31 criteria) while PF is the second most used criteria in career selection. Table 2-5 in Appendix C shows the fraction of criteria used by students that been classified into four areas.

Consistency checking: Consistency check is a common practice in AHP to evaluate the scoring made by the whole team. In previous studies by Siew *et al.* (2015) consistency check is performed for all criteria. In this study, we performed consistency check for the group that has the highest score of criteria. The detailed calculation of the consistency check for the group can be referred in Table 6 in Appendix D. Steps of performing consistency check are summarized as.

Step 1 (Comparison table): Comparison table for each criterion is being taken and put into the normalization Table 1. The selected group taken for consistency check is based on the highest criteria scored, (i.e., discipline being the highest scored). In this example, since group 1 from 7BAV has shown highest criteria score (after pairwise comparison) which is 0.5221; therefore this group comparison is being tested for consistency check.

Step 2 (Normalization table): The comparison rating was then put into normalization table by averaging the comparison value with the total from the comparison table. The total average of values is put in the column labeled as row average. Consistency values are calculated by performing the multiplication of comparison table with the row average. The result of the multiplication is shown in the consistency row of the normalization table. The calculation of the values can be referred in Table 4 in Appendix C.

Table 1: Criteria comparison table

	Criteria: performance		
Variables	Quality assurance	Project engineer	Product/process engineer
Quality assurance	1.0000	0.3333	1.5000
Project engineer	3.0000	1.0000	0.3333
Product/process engineer	0.6667	3.0000	1.0000
Total	4.6700	4.3300	2.8300

Table 2: Contitency index calculation

Comparison items and index	Values
Number of comparisons (criteria)	3
Average consistency	1.28
Consistency index	-0.86
Random consistency index	0.58
Consistency	-1.49
Consistent?	Yes

Table 3: Random index (Mammadova and Jabrayilova, 2014)

m	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.51

Step 3 (Consistency index and random index): Criteria comparison is considered as consistent if the value of Consistency Ratio (CR) is <10% or 0.1 (Saaty, 1980) CR = CI/RI and CI = (λ_{max}-N)/(N-1). From the normalization table in Table 3, the average consistency values will be used to acquire the value from the Random Index (RI) table.

From Table 2 and 3 number of comparisons is a number of criteria compared for this study. Average consistency is the total values of consistency from Table 2 divide by the number of criteria compared (3.83 divided by 3 equals to 1.28. The consistency index value is acquired by calculating (average consistency minus by the number of criteria compared) divided by (number of criteria compared -1.00) which is equal to -0.86. Random consistency index Table 2 by Saaty (1980) was used to acquire the random value. In Table 5 above, the random index for the criteria above is 0.58 based on the n-value of the criteria. To determine the rate of consistency, consistency index value (-0.86) to be divided with the random consistency index (0.58) which equals to -1.49 or <0.1.

CONCLUSION

This study is not only helped to identify MCDM used by students in selecting their career of choice

but has also helped the students to understand one of the methods that can be used to evaluate career more objectively. This study gives a new perspective to the application of AHP and MCDM whereby students is using their criteria of preferences rather than preset criteria which might not be relevant to them. Students were also needed to set their own scale instead of using the common range by Saaty (1980) that is widely used in other studies related to AHP method. To ensure the integrity of decision, consistency of the decision is evaluated to one of the group.

This study is significant in identifying the career selected by students at the university level as well as the most important criteria in the decision-making process. In this study, consistency checking is only performed to a group that scored highest EV for one of the criteria. In future, consistency checking is expected to be performed by all groups involved in the experiment.

APPENDIX

Appendix A: Preset criteria used by previous studies:

Table 1: Preset Criteria used by some other researchers

Author	Focus of study	Criteria used
Siew *et al.* (2015)	Career selection among University Tunku Abd Rahman student's	Job related: income and benefit, economy demand, challenges work environment, work life balance and academic qualification Personal preferences: personal aptitude, personal interest, work/personal interest Societal: gender, friend influence, family influence
Kilic and Cevikcan (2011)	Career selection among Istanbul Technical University student's	The revenue of the job; loving the job; social position of the job; social assurance of the job; business environment of the job; physical conditions of the job
Lokare and Jadhav (2016)	Best course selection using AHP and TOPSIS after HSC	interest; opportunity for employment; fee for the program; duration of the study
Adiguzel (2010)	Determination of University selection	Achievement of academic; job opportunities for graduates; distance of the university to the origin place, economic status; moreover, the opportunities for the accommodation of the city

Appendix B: Flow of study process:

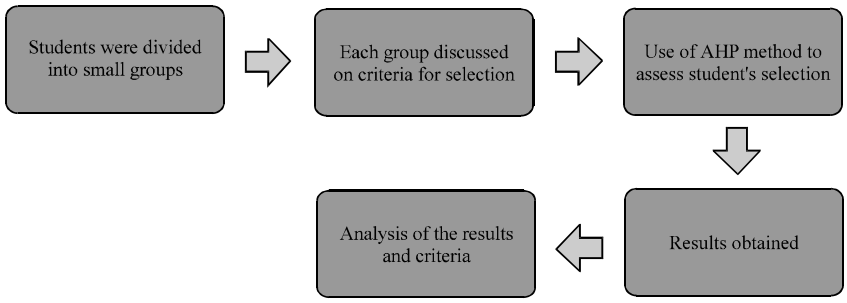

Fig. 1: Study process (drawn by researcher)

Appendix C: AHP process used by students:

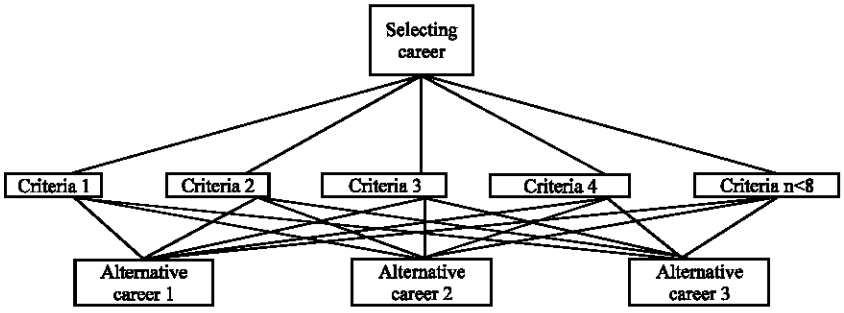

Fig. 2: AHP process used by each group to select a career (drawn by reearcher)

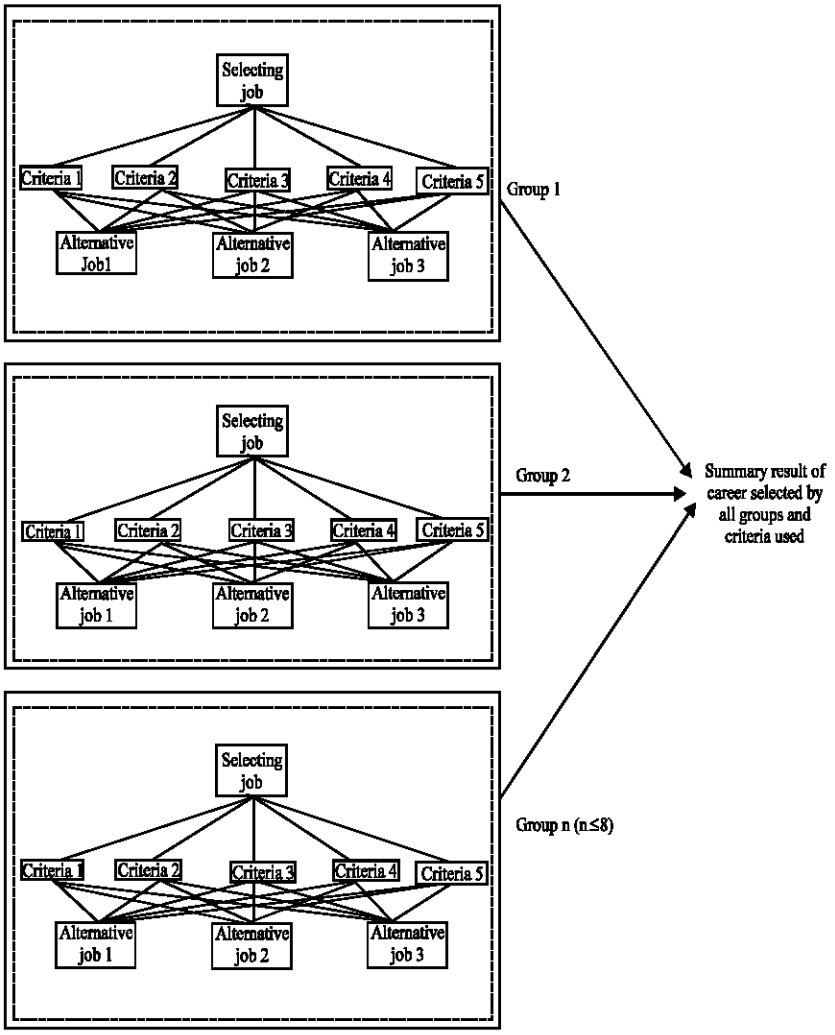

Fig. 3: Summary result of career selected by all groups and criteria used

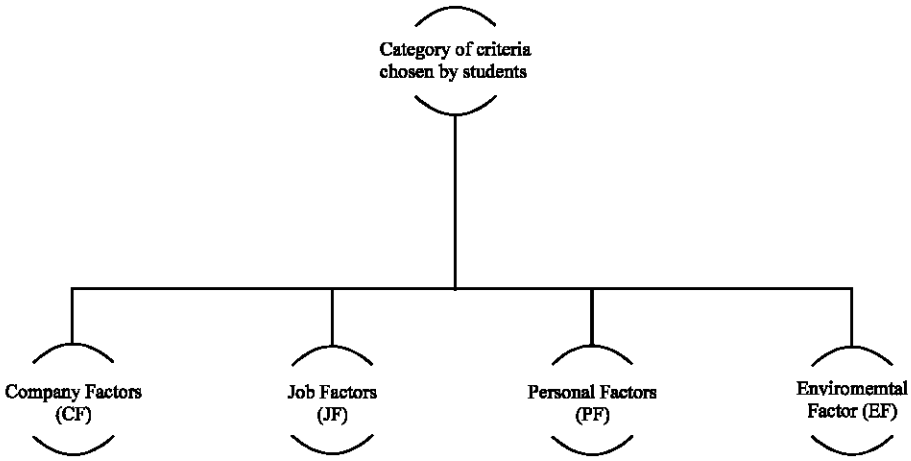

Fig. 4: Summary of criteria used by students

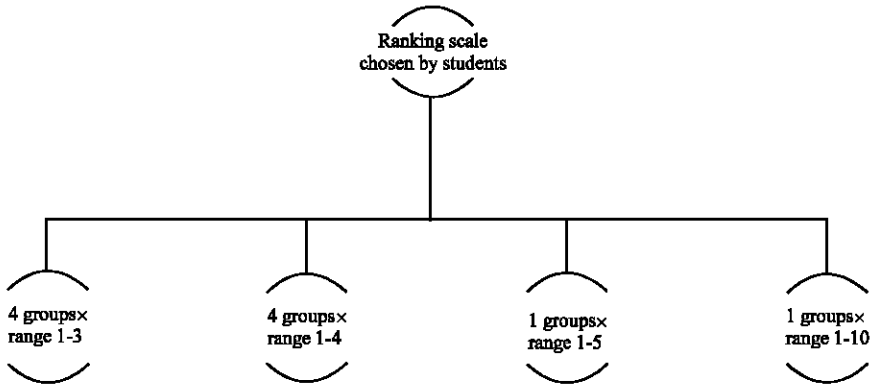

Fig. 5: Summary of ranking scale used by students (drawn by researcher)

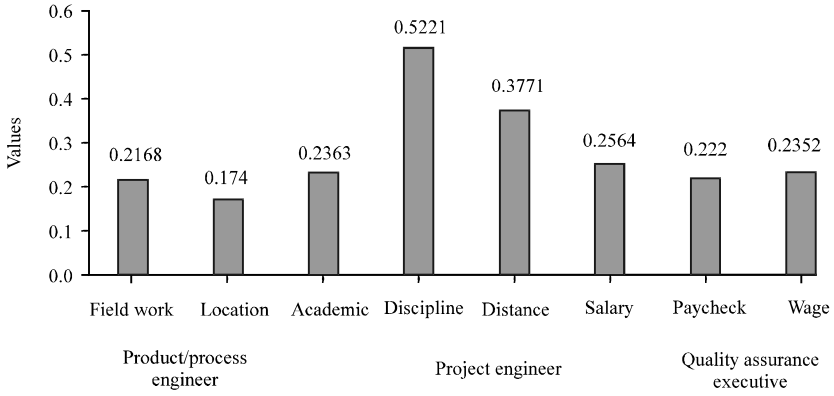

Fig. 6: Career selected and the high importance criteria

Table 2: Fraction of criteria classified into four areas

	Factors			
List of groups	Company (31 criteria)	Environmental (9 criteria)	Job (1 criteria)	Personal (15 criteria)
7BAV class				
1	Performance (company), paycheck, required experience	Adaptability	None	Passionate, self-motivated, language, discipline
2	Related field skill, experience, expert area, certification knowledge, problem-solving situation		None	Academic, soft skills
3	Perks, advancement opportunity, benefits	Superior (boss), culture, working environment	None	Job security, location
4	Safety, company reputation, benefits, paycheck	Culture	None	Prospects, distance, job scope interest
5	Skills, salary, profession level, required experience	Working hour	Work pressure	Self-qualification,fieldofwork
6	Qualification by company, skills, experience required wage, company benefits	Working time	None	Location, self-interest
7xBAV class				
1	Skills required, salary, workload, benefit	Working hours	None	None
2	Salary, company benefit	Working Hours	Type of employment	Distance

Table 3: Normalization table

Variables	Quality assurance	Project engineer	Product/process engineer	Row average	Consistency
Quality assurance	0.21	0.08	0.53	0.27	0.98
Project engineer	0.64	0.23	0.12	0.33	1.28
Product/process engineer	0.14	0.69	0.35	0.40	1.57
Total	1.00	1.00	1.00	1.00	3.83

Table 4: List of groups with the selected career and the criteria with highest

Group lists	Selected career	Criteria with higher eigen values	Eigen values
1	Project engineer	Discipline	0.5221
2	Project engineer	Academic	0.2363
3	Product/process engineer	Location	0.1740
4	Quality assurance executive	Paycheck	0.2220
5	Product/process engineer	Field of work	0.2168
6	Quality assurance executive	Wage	0.2352
1	Project engineer	Salary	0.2564
2	Project engineer	Distance	0.3771

Table 5: List of detailed criteria and ranking scale listed by students

Criteria	Scale
7BAV	
Group 1	
Performance (company) (CF)	1-4
Language (PF)	
Discipline (PF)	
Passionate (PF)	
Self-motivated (PF)	
Adaptable (EF)	
Pay check (CF)	
Experience (required) (CF)	
Group 2	
Academic (PS)	1-3
Related field skill (CF)	
Experience (required) (CF)	
Expertise area (CF)	
Certification (CF)	
Knowledge (CF)	
Problem solving situation (PF)	
Soft skills (PF)	
Group 3	
Location (EF)	1-3
Perks (CF)	
Advancement (CF)	
Security (PF)	
Environment (EF)	
Benefits (CF)	
The boss (EF)	
Culture (EF)	
Group 4	
Future prospects (PF)	1-10
The Culture (EF)	
Pay check (CF)	
Benefits (CF)	
Distance (PF)	
Reputations of the company (CF)	
Job scope interest (PF)	
Safety (CF)	
Group 5	
Skill (required) (CF)	1-3
Qualification (self) (PF)	
Salary (CF)	
Level (job) (CF)	
Experience (required) (CF)	
Field (PF)	
Hour (EF)	
Pressure (JS)	
Group 6	
Qualification (required) (CF)	1-3
Skill benefits (CF)	
Location (EF)	
Interest (PF)	
Experience (required) (CF)	
Wage (CF)	
Work time (EF)	
Company benefits (CF)	

Table 5: Continue

Criteria	Scale
7xBAV	
Skill (PF)	1-5
Salary (CF)	
Workload (CF)	
Benefit (CF)	
Working hours (CF)	
Type of employments (CF)	1-4
Working hours (CF)	
Salary (CF)	
Distance (EF)	
Benefit (CF)	

Appendix D: Consistency check result:

Table 6: Consistency check result

Variables	Quality assurance	Project engineer	Product/process engineer	Row average	Consistency	Number of comparisons	3
Criteria: performance							
Quality assurance	1(0.21)	0.3333 (0.08)	1.5 (0.53)	0.27	0.98	Average consistency	1.28
Project engineer	3 (0.64)	1 (0.23)	0.3333 (0.12)	0.33	1.28	Consistency index	-0.86
Product/process engineer	0.6667 (0.14)	3 (0.69)	1 (0.35)	0.4	1.57	Random consistency index	0.58
Total	4.67 (1)	4.33 (1)	2.83 (1)	1	3.83	Consistency	-1.49
						Consistent	Yes
Criteria: language							
Quality assurance	1 (0.21)	0.3333 (0.17)	1.5 (0.38)	0.25	0.78	Average consistency	1.05
Project engineer	3 (0.64)	1 (0.50)	1.5 (0.38)	0.51	1.63	Consistency index	-0.97
Product/process engineer	0.6667 (0.14)	0.6667 (0.33)	1 (0.25)	0.24	0.75	Random consistency index	0.58
	4.67 (1)	2 (1)	4 (1)	1	3.16	Consistency	-1.68
						Consistent?	Yes
Criteria: discipline							
Quality assurance	1 (0.22)	2 (0.44)	0.3333 (0.17)	0.28	0.89	Average consistency	1.08
Project engineer	0.5 (0.11)	1 (0.22)	0.6667 (0.33)	0.22	0.69	Consistency index	-0.96
Product/process engineer	3 (0.67)	1.5 (0.33)	1 (0.50)	0.5	1.67	Random consistency index	0.58
	4.5 (1)	4.5 (1)	2 (1)	1	3.25	Consistency	-1.65
						Consistent?	Yes
Criteria: self motivated							
Quality assurance	1 (0.17)	0.3333 (0.12)	0.5 (0.23)	0.17	0.52	Average consistency	1.03
Project engineer	3 (0.50)	1 (0.35)	0.6667 (0.31)	0.39	1.2	Consistency index	-0.99
Product/process engineer	2 (0.33)	1.5 (0.53)	1 (0.46)	0.44	1.37	Random consistency index	0.58
	6 (1)	2.83 (1)	2.17 (1)	1	3.08	Consistency	-1.7
						Consistent?	Yes
Criteria: passionate							
Quality assurance	1 (0.18)	0.6667 (0.29)	0.3333 (0.12)	0.2	0.6	Average consistency	1.05
Project engineer	1.5 (0.27)	1 (0.43)	1.5 (0.53)	0.41	1.29	Consistency index	-0.98
Product/process engineer	3 (0.55)	0.6667 (0.29)	1 (0.35)	0.39	1.25	Random consistency index	0.58
	5.5 (1)	2.33 (1)	2.83 (1)	1	3.15	Consistency	-1.68
						Consistent?	Yes
Criteria: adaptable							
Quality assurance	1 (0.35)	0.6667 (0.29)	3 (0.55)	0.39	1.25	Average consistency	1.05
Project engineer	1.5 (0.53)	1 (0.43)	1.5 (0.27)	0.41	1.29	Consistency index	-0.98
Product/process engineer	0.3333 (0.12)	0.6667 (0.29)	1 (0.18)	0.2	0.6	Random consistency index	0.58
	2.83 (1)	2.33 (1)	5.5 (1)	1	3.15	Consistency	-1.68
						Consistent?	Yes
Criteria: pay-check							
Quality assurance	1 (0.21)	0.3333 (0.17)	1.5 (0.38)	0.25	0.78	Average consistency	1.05
Project engineer	3 (0.64)	1 (0.50)	1.5 (0.38)	0.51	1.63	Consistency index	-0.97
Product/process engineer	0.6667 (0.14)	0.6667 (0.33)	1 (0.25)	0.24	0.75	Random consistency index	0.58
	4.67 (1)	2 (1)	4 (1)	1	3.16	Consistency	-1.68
						Consistent?	Yes
Criteria: experience							
Quality assurance	1(0.50)	1.5 (0.47)	3 (0.55)	0.51	1.53	Average consistency	1.00
Project engineer	0.6667 (0.33)	1 (0.32)	1.5 (0.27)	0.31	0.92	Consistency index	-1.00
Product/process engineer	0.3333 (0.17)	0.6667 (0.21)	1 (0.18)	0.19	0.56	Random consistency index	0.58
	2 (1)	3.17 (1)	5.5 (1)	1	3.01	Consistency	-1.72
						Consistent?	Yes

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