Analytical Hierarchy Process for New Student Allocation Problem

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***Abstract*— Semester one students in Ungku Omar Polytechnic are allocated to each class randomly based on their registration number without referring to their real intelligence level, knowledge, skills and also their performance. Therefore, in each class, there are students with multiple intelligence gap and skills. It is very difficult to give good educational service for large number of students with high diversity of achievements or skills. In this paper, AHP is used to cluster a group of semester one students from Information & Communication Technology (ICT) Department to minimize intelligence gap and skills in each class. Pre-Test and Post-Test are used to evaluate students' performance and a questionnaire is distributed to the students before and after clustering process to evaluate student's motivational level. The research findings showed that students who were clustered with minimum intelligent gap and skills for their academic session shows a better performance and higher motivational level as compared to students in a cluster with multiple intelligent gap and skills.**

***Index Terms*— Analytical Hierarchy Process (AHP); Motivational level; New Student Allocation Problem (NSAP); Students' performance.**

I. INTRODUCTION

The New Student Allocation Problem (NSAP) is one of clustering problems to allocate students into few classes with minimum intelligence gap and skills per class with its maximum capacity. Grouping of students is very essential in education process. A class is a group of students, which should consist of similar students [1]. This topic is essential as it is a great challenge to provide best educational service for large number of students with wide diversity in their achievements and skills [2].

In Ungku Omar Polytechnic, the process in allocating new students into classes is based on their registration number. The officers from Registration Unit will select the first group by referring to the registration numbers in an ascending order and grouped them into the first class. The total number of students per class is depending on the total number of students registered but the maximum capacity is 40 students per class due to base on limited computer lab capacity. For example, if the total students for each program are 70 students, then they will be divided into two classes, which are 35 students per class. The main problem is allocation of new students is not based on any specific criteria, students intelligent or skills level. It is done randomly based on first come first serve concept only. Thus, in each class there are multiple intelligence, knowledge, performance and skills level. The proposed approach is to use AHP as a fair solution to cluster the new students to ensure the minimum intelligence gap and skills in each class.

There are many approaches used in solving NSAP. Many researches use application of Genetic Algorithm (GA) [2][3]. Other than that, researchers used Fuzzy C-Means algorithm (FCM)[4], K-Means Clustering Algorithm [5] and Bayesian Approach [6]. However, there are some researchers who combine two techniques such as Analytical Hierarchy Process (AHP) and k-Means Clustering to get the best result in solving resource allocation such as [7][8][9].

In this paper, the researchers apply an Analytical Hierarchy Process (AHP) to solve New Student Allocation Problem (NSAP) at Registration Unit in Ungku Omar Polytechnic. The AHP developed by Saaty [10][11] provides a flexible and easily understood way of analyzing complicated problems. It is a multiple criteria decision making techniques that allow subjective as well as objective factors to be considered in decision making process [12][13][14][15][16]. Therefore, the researcher's focuses on solving NSAP by using six steps in AHP to allocates students into few classes with minimum intelligence gap in each class and the number of students in each class does not exceed its maximum capacity [10][17]. The proposed solution is tested using real data from the Ungku Omar Polytechnic to see whether students' performance and motivational level is improving by implementing AHP.

Therefore, in this paper, first section describes the introduction of NSAP, current process, problem, Literature Review and AHP. Second section discusses on the methodology, which describe on research methodology, population of the research, research instrument, data analysis and implementation of AHP. Then, third section represents the results and discussions of student's performance and motivational level. Finally, fourth section consists of conclusion of this paper.

II. METHODOLOGY

A. Research Methodology

This section elaborates a process of decision-making procedure in clustering the new students. The process was separated into three main levels, which are data gathering,

preparation and decision-making [9] . During of data gathering phase, Literature Survey (LS) is used to gain information about New Students Allocation Problem (NSAP), the process, procedure and also the limitation of NSAP. Through the LS, AHP is chosen to cluster new students into their classes to minimize multiple intelligence and skills. The relevant literature from various materials were reviewed and analyzed by the LS by using academic search engines. After that, interviews with Students Affair Department Officers are conducted to get a real situation in handling registration process especially on how students is allocating into their class, constraints and limitation.

Then, in the second phase, which is data preparation, interview is conducted to collect data from experts or decision-makers corresponding to the hierarchy structure, in the pairwise comparison of alternatives on a qualitative scale. If all the requirements are met, the third phase starts. Microsoft Excel is used to rank the new students into their classes with minimum intelligent gap and skills based on Analytical Hierarchy Process (AHP). To evaluate the effectiveness of the process, mean of Pre-Test and Post-Test and student's motivational level from Control Group and Experimental Group is calculated by using SPSS. Lastly, the result is analyzed and summary is determined.

B. Population of the Research

In this paper, the focus area is at Information and Communication Technology (ICT) Department. The samples are consists of 40 students of two classes with 20 students for each class, which is DIP1A and DIP1B in December 2014 Session. This study is focusing on Problem Solving and Program Design (DFC1023) course because in this course it covers about all the basic knowledge of programming. Besides, it is a pre-requisite for other programming course in the next semester. To avoid bias in this study, the same lecturer conducts both classes.

C. Research Tools

Research tools that have been used in this research are Pre-Test and Post-Test for evaluating students' performance while questionnaire is used to evaluate students' motivational level.

Pre-Test is given to the Control Group while Post-Test is given to the Experimental Group. The types of questions are problem solving and the total mark is 10. The problem solving questions is created to evaluate critical thinking of students because it is the best practice and skills required to be an excellent student in programming.

The questionnaire is prepared to suit the requirement of this study and the total score for 35 items is 175 marks [18]. SPSS is used to analyze the data. However, pilot test is used to validate the questionnaire. Ten of students from semester 1 in Diploma of Information Security (DIS) Program are selected to run the pilot test.

D. Analyze Data

The total mark of Pre-Test and Post-Test are 10 marks respectively. The marks are converted to percentage to match with the scale of the mark as shown in Table 1. However, marks to evaluate students' motivational level are remaining the same, which are 175 marks. The following table is the scale of the Pre-Test and Post-Test score together with their level of students' understanding.

Result for Pre-Test and Post-Test for each student at different group (Control Group and Experimental Group) is recorded and will be analyzed in next section. The result for each student will be compared to evaluate the effectiveness of allocation the new students into their classes' by using AHP in term of improving student's performance. The procedure of Data Analysis is shown in Figure 1.

Table 1
Score for Pre-Test and Post-Test

Score	Level of students understanding
80 - 100	Excellent
60 - 79	Good
40-59	Average
0-39	Weak

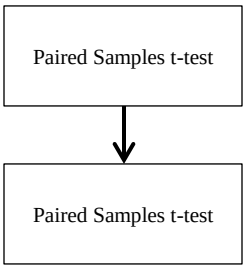

Figure 1: Procedure of Data Analysis

E. Implementation of Analytical Hierarchy Process (AHP)

There are six steps in AHP as follows:

Step 1: The first structured interview was designed according to the input received by Literature Survey (LS). The interview involved three experts consist of lecturers and Head of Program represented in order by (R1), (R2) and (R3) respectively. The objective of the interview session is to get the short listed criteria to rank new students. The relevant criteria were identified by asking the respondents to rate each factor using the four-point scale of "Not important (1 to 3)", "Some-what important (4 to 5)", "Important (6 to 7)" and "Very important (8 to 9)" [17]. The process of selecting the most important criteria was decided by accepting the criteria with average above 7.

Besides, for student solution, a description of the sub criteria has been prepared according to three important criteria selected as the results of previous step with the consideration of literature. Based on the identified sub-criteria selected from the second structured interview, the design and modification have been completed similarly to the first step. In order to decide on the most important sub-criteria, it was recommended to take the sub-criteria with average result above 7. Then, the problem is illustrated in a hierarchy structure consist of goal, criteria, sub-criteria and alternatives as shown in Figure 2.

Step 2: The third interview was conducted with the same respondents to make a pair wise comparison of various criteria on a qualitative scale as described below. The expert's persons and Decision Makers rated the comparison as shown

in Figure 3 and the comparisons are made for each criterion and converted into quantitative numbers as per Figure 4. However, the number of comparison is depending on the number of criteria and sub-criteria, which are stated in level 2 and 3 in Figure 2. The formula to get the number of comparison is shown in Table 2. The result of comparison for criteria is shown in Table 3.

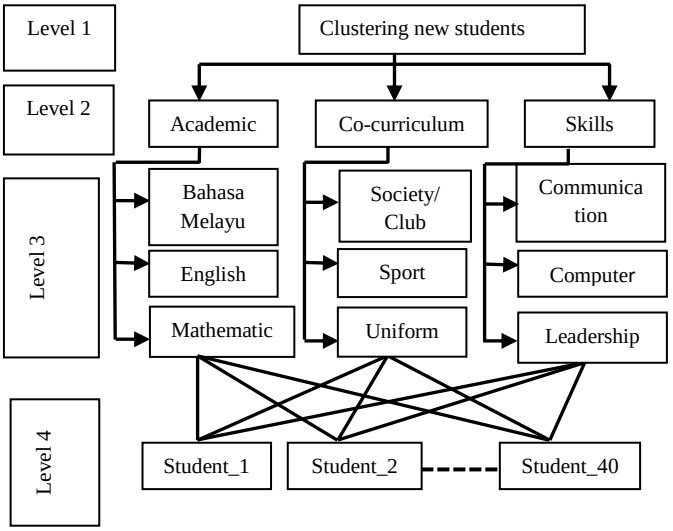

Figure 2: Hierarchy structure for ranking the new students

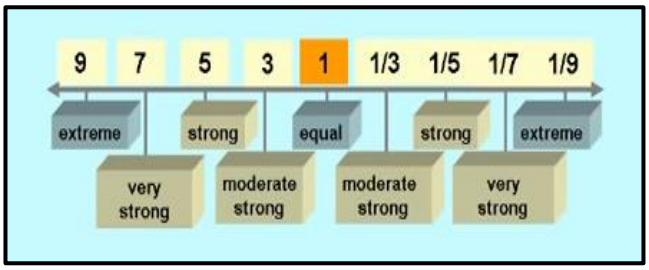

Figure 3: Format for pair wise comparisons

Option	*Numerical value(s)*
Equal	1
Marginally strong	3
Strong	5
Very strong	7
Extremely strong	9
Intermediate values to reflect fuzzy inputs	2, 4, 6, 8
Reflecting dominance of second alternative compared with the first	Reciprocals

Figure 4: Gradation scale for quantitative comparison of alternatives

Table 2
Number of comparisons

Number of things	1	2	3	4	5	6	7	n
Number of comparisons	0	1	3	6	10	15	21	$\frac{n(n-1)}{2}$

Table 3
Result for comparison of criteria

Criteria	Factor weighting score																	Criteria
	More importance than								Equal	Less important than								
Academic	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Co-curriculum
Academic	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Skills
Co-curriculum	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Skills

Step 3: The comparisons in pair of various criteria obtained at step 2 are organized into a square matrix. The result of comparison matrix and pair wise comparison for criteria is shown in Table 4.

Step 4: This step is to **normalize the matrix** by adding the numbers in each column. Then, every data in the column is divided by the column sum to yield its normalized score. The sum of each column is 1. The result of each criterion is shown in Table 5. From the result, the highest average score for the table is bold. It shows that the criterion is very important compare to the others.

Table 4
The results of comparison matrix and pair wise comparison for criteria

Criteria	Academic	Co-curriculum	Skills
Academic	1.00	7.00	5.00
Co-curriculum	0.14	1.00	0.33
Skills	0.20	3.00	1.00
Total	1.34	11.00	6.33

Table 5
The result of highest average score for criteria

Criteria	Academic	Co-curriculum	Skills	Total	Average	Weight
Academic	0.75	0.64	0.79	2.18	**0.73**	**73%**
Co-curriculum	0.10	0.09	0.05	0.24	0.08	8%
Skills	0.15	0.27	0.16	0.58	0.19	19%
Total	1.00	1.00	1.00			

Step 5: The consistency ratio is calculated and its value is checked. The purpose for doing this is to make sure that the

original preference ratings were consistent. There are 3 steps to arrive at the consistency ratio:

i. Calculate the consistency measure ($\lambda \max - n$).
ii. Calculate the Consistency Index (CI).

$$CI = \frac{\lambda \max - n}{n - 1} \quad (1)$$

**n= order of matrix*

iii. Calculate the consistency ratio (CI/RI where RI is a Random Index).

$$CR = \frac{CI}{RI} \quad (2)$$

**RI is provided by AHP as shown in Table 6.*

Table 6
The CI of a randomly-generated pair wise comparison matrix

n	**1**	**2**	**3**	**4**	**5**
RI	0.00	0.00	0.58	0.9	1.12
n	**6**	**7**	**8**	**9**	**10**
RI	1.24	1.32	1.41	1.46	1.49

**n=order of matrix*
**Random inconsistency indices for n=10*

The results are shown as follows. From the results, all the CR is below of 0.1. So it is considered acceptable.

Criteria:

$$\lambda\, max = 1.34\,(0.73) + 11.00\,(0.08) + 6.33\,(0.19) = 3.0609$$

$$CI = \frac{3.0609 - 3}{2} = 0.0305$$

$$CR = \frac{0.0305}{0.58} = \mathbf{0.053} < 0.10\ (acceptable)$$

Step 6: From step 1 until 5, the important criteria and sub-criteria are determined based on weight. So, to cluster new students, the weight of all the alternatives, which is student_1 until student_40 is calculated, based on three sub-criteria. The value of Mathematics is taken from SPM result, which scales from 1 to 9 based on SPM grading system as shown in Table 7. Same like the value of Society/Club. The value is taken from their result at secondary school and the scale is also referring to the SPM grading system as shown in table 7. However, for Communication Skills, the students are requested to evaluate their skills by their own based on scale 1 to 9 at registration day as shown in Table 8. Total score and average are calculated for each of the students so that ranking will be done based on the average value. Then the students are clustered into their classes based on the scale as shown in table 9. From that data, there are three groups formed which is Group_1 (good), Group_2 (average) and Group_3 (weak). There are 12 students allocated in Group_1, 20 students in Group_2 and 8 students in Group_3. In each group, it is consists of students which have minimum intelligent gap and skills.

Table 1
SPM grading system

STATUS	RATING
Excellent	9
	8
Good	7
	6
Average	5
	4
	3
Weak	2
	1

Table 2
Scale to evaluate students' skills

GRED	RATING
A+	9
A	8
A-	7
B+	6
B	5
C+	4
C	3
D	2
E	1

Table 3
Scale to cluster new students into their classes

STATUS	RATING
Excellent	8.00 to 9.00
Good	6.00 to 7.99
Average	4.00 to 5.99
Weak	0.00 to 3.99

III. Results And Discussion

A. Result

Dependent variable in this research are marks for Pre-Test and Post-Test to evaluate students' performance and also score from questionnaire to evaluate students motivational level. Independent variable is Control Group which taken before clustering with AHP and Experimental Group after clustering with AHP is implemented. Research Hypothesis is shown in Table 10 and the following is the result after analyzing the data.

B. Students' Performance

From the result, there are 5 students which is 12.5% are able to maintain the performance while the performance of other 12 students which is 30% are declining. However, the performance of 23 students, which is 57.5%, is increasing due to AHP. Besides, mean score for Pre-Test is 72.25 and Post-Test is increased to 82.38 while the mean value for difference between Pre-Test and Post-Test are 10.13.

Based on Table 11, Standard Deviation is 18.929, t value is 3.383 and p value is 0.002. This means p value is <0.05. So, based on [19] and [20] , the result shows significant differences in mean score between Experimental and Control Group because the p value is <0.05. Mean score for Experimental Group is 82.38, which is higher than Control Group with score of 72.25, and total marks to evaluate students' performance are 100. Therefore, H_{a1} is accepted in Problem Solving and Program Design (DFC1023) course. Based on the table, the research finding shows that student who are in a cluster with minimum intelligent gap and skills for their academic session show a better performance as compared to students in a cluster with multiple intelligent gap and skills.

Table 4
Research Hypothesis

Hypothesis	Description
H_{01}:	There is no difference in student's achievement either they are in a cluster with minimum intelligent gap or skills or they are in cluster with multiple intelligent gap and skills in their academic session.
H_{02}:	Students who are in a cluster with minimum intelligent gap and skills for their academic session shows a better performance as compared to students in a cluster with multiple intelligent gap and skills.
H_{02}:	There is no difference in term of motivational level of the students either they are in a cluster with minimum or multiple intelligent gap and skills.
H_{a2}:	Students who are in a cluster with minimum intelligent gap and skills have higher motivational level than students in a cluster with multiple intelligent gap and skills.

Table 5
Paired Samples t-test shows the differences for test achievement between Experimental and Control Group.

Experimental Group		Control Group		SD	t	P
N	Mean	N	Mean			
40	82.38	40	72.25	18.929	3.383	0.002

C. Students' Motivational Level

From the result, there are 31 students which is 77.5% are able to improve the motivational level while the performance of 9 students which is 22.5% are decreasing. Besides, mean score for Motivational Level before and after clustering new students with AHP are 116.20 and 122.43 respectively. The mean for difference between before and after clustering new students with AHP is 6.23.

Based on Table 12, Standard Deviation is 8.463, t value is 4.652 and p value is 0.000. This means p value is <0.05. So, based on [19] and [20], the result shows the significant differences in mean score between Experimental and Control Group because the p value is <0.05. Mean score for Experimental Group is 122.43, which is higher than Control Group with score of 116.20, and total marks to evaluate student's motivational level are 175. Therefore, H_{a2} is accepted in Problem Solving and Program Design (DFC1023) course. Based on the table, the research finding shows that students who are in a cluster with minimum intelligent gap and skills have higher motivational level than students in a cluster with multiple intelligent gap and skills.

Table 6
Paired Samples t-test shows the differences for Motivational Level between Experimental and Control Group.

Experimental Group		Control Group		SD	t	P
N	Mean	N	Mean			
40	122.43	40	116.20	8.463	4.652	0.000

IV. CONCLUSION

A quality of teaching and learning activities can be well established if serious attention is given in allocating the new students into their classes. In Ungku Omar Polytechnic, semester one students are allocated to each class randomly based on their registration number without referring to their real intelligence level, knowledge, skills and also their performance. Therefore, in each class, there are students with multiple intelligence gap and skills. So, in this paper, AHP is used to cluster a group of semester one students from Information & Communication Technology (ICT) Department to minimize intelligence gap and skills in each class. The research finding shows that students who cluster with minimum intelligent gap and skills for their academic session shows a better performance and higher motivational level as compared to students in a cluster with multiple intelligent gap and skills. However, as time goes by, a variety of behavior is constantly changing after the establishment of the index system and mining model, so they need constantly updated to be more suitable for the current practical application. For future work, AHP tools such as Expert Choice can be used to cluster a large amount of data. So if this approach is cosidered, then the performance of Analytical Hierarchy Process is improved for large samples of data set that are also distributed in nature.

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