Scheduling of Student-Development Activities via an Integration of Compromised-AHP and Transportation Model

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Abstract

One of the main challenges to schedule student-development activities in a university is to avoid time conflicts that may affect participation from the students. This can be achieved by having a proper planning and scheduling of student-development activities. In this paper, we demonstrate how Compromised-Analytic Hierarchy Process (C-AHP) and transportation model which a subset of integer programming (IP) models were utilized to schedule a set of student activities to be run by the Universiti Utara Malaysia's Student Body for the 2018/2019 academic year. C-AHP was used to determine the organizer's activity-month preference values, while transportation models were constructed to schedule a set of student activities that can be executed successfully with high participation rates from the students. Two different transportation models, namely Model A and Model B were constructed. Model A was formulated without the organizer's month preference to conduct the activities, whereas Model B took into consideration the organizer's month preference. For Model A, the optimal result indicated that the activities scheduled were concentrated towards the earlier months of the academic year. On the other hand, the scheduling of activities provided by the output from Model B was better distributed across the months of the academic year. The methods applied in this study will be useful to be implemented by organizations with many subunits in the managing and planning of activities in order to avoid time conflicts among activities, which in turn will minimize the chances of activity failure.

Keywords: Student activities scheduling; C-AHP; transportation model.

1. Introduction

Planning and scheduling of student development activities particularly at a university level are not easy due to various reasons. Some of the more obvious reasons among others are:

- Conflict of interest between the planners and the intended participants.
- Budget constraints.
- Clashes of events whereby the events are intended for the same pool of participants.

At the Office of Student Affairs, Universiti Utara Malaysia (UUM), the planning of student development activities for the 2018/2019 academic year had been completed by the newly appointed Student Body before the end of the 2017/2018 academic year. The identification and selection of the activities to be executed along with the budget to be allocated for each selected activity were done via a few stages as reported in Nazri et al. (2017):

- Stage 1: Group brainstorming session to generate a list of potential activities to be conducted along with the expected budget needed to run each activity. A total of 40 activities was suggested by the members of the Student Body.
- Stage 2: Ranking of activities based on the preference of student community using Compromised-Analytic Hierarchy Process (C-AHP).
- Stage 3: Selecting the final activities to be executed based on students' preference weight, student development Chickering's Theory, and budget constraint via 0-1 integer programming (0-1 IP) model. A total of 29 activities was finally selected.

The finalized 29 selected activities targeted for students from various academic years and the responsible Student Body working committee to execute the activities are as listed in Table 1.

Table 1: List of activities, the targeted students based on their academic year, and the Student Body working committee in charge

List of activities	Targeted Students (Year)
Working Committee: Sports Affairs	
1: Hiking with Nature	1,2
2: 1 Malaysia Run-A-Way	1,2,3,4
3: Vice Chancellor's Trophy: Soccer	1,2,3,4
Working Committee: Academic Affairs	
4: Step to Better English	1,2
Working Committee: Career and Alumni Affairs	
5: Media Grooming	3,4
6: Leadership Academy	3,4
7: Walk-in Interview	4
8: Young CEO Development Program	3,4
9: *Sirih Pulang ke Gagang*	1,2,3,4
Working Committee: International and Mobility Affairs	
10: Global Night 2018/2019	1,2,3,4
11: Backpackers Volunteer – Jogjakarta	3,4
12: Cultural Exchange Day	1,2,3,4
13: Rules & Regulations in Malaysia	1,2,3,4
Working Committee: Student Welfare and Entrepreneurial Affairs	
14: Princess Day	1,2
15: 3K Carnival	1,2,3,4
16: Big Screen	1,2,3,4
17: E-Business Carnival	2,3,4
18: Business Talk	2,3,4
19: Industrial and Product Innovation Visit with CEO	3,4
Working Committee: Cultural Affairs	
20: Acousticity	1,2,3,4
21: Zapin Festival	1,2,3,4
22: Knowing about Village in Malaysia	1,2,3,4

23: Cultural Art Competition	1,2,3,4
24: Workshop on Traditional Delicacies	1,2,3,4
Working Committee: General Affairs	
25: *Ceramah Perdana*	1,2,3,4
26: UUM Quran Hour	1,2,3,4
27: UUM MUN	1,2,3,4
28: Mass *Solat Hajat* and Breaking the Fast Gathering	1,2,3,4
29: Hari Raya Celebration	1,2,3,4

Having identified the activities, the next issue to be tackled was on the scheduling of the activities to ensure the activities can be executed successfully and the rate of participation for each activity is high.

The objective of this paper therefore is to report on the process followed by the UUM Student Body in scheduling the activities to satisfy two different objectives with respect to several constraints. Two different scheduling models were developed which are, i) to schedule the activities based only on the suitability of the activity-month mapping, and ii) to schedule the activities based on both the suitability of the activity-month mapping and the working committee's activity-month mapping-preference weight. Meanwhile, the constraints and the conditions to be adhered to are, i) certain activities can be run in certain months only, ii) the total activities for each month, except for December 2018 and June 2019, should not exceed four activities, and iii) the total activities for December 2018 and June 2019 should not exceed two activities since the final examination week for the students normally starts in late December and late June.

2. The Scheduling Approach

The scheduling process involved several stages. The stages involved were as follows:
Stage 1: The mapping of activity and month to identify the activity-month suitability. Each working committee which later would be responsible to organize the respected activities was asked to map its activities with the suitable months that those activities can be run. The result is as given in Table 2.

Table 2: Activity month-suitability-requirements for activity scheduling

Act. No.	2018				2019							
	Sept	Oct	Nov	Dec	Jan	Feb	Mac	Apr	May	June	July	Aug
1	√	√	√				√	√	√			
2		√	√	√			√	√	√			
3		√	√				√	√				
4		√	√	√			√	√	√	√		
5		√	√	√			√	√	√	√		
6		√	√	√	√	√	√	√	√	√	√	
7		√	√	√			√	√	√	√		
8		√	√	√	√	√	√	√	√	√		
9		√	√				√	√	√			
10	√	√	√	√		√	√	√	√	√		
11					√						√	√
12		√	√	√			√	√	√			
13	√	√	√	√			√	√	√	√		
14		√	√	√			√	√	√	√		
15		√	√				√	√	√			
16	√	√	√	√		√	√	√	√	√		

17		√	√	√			√	√	√	√		
18		√	√	√			√	√	√	√		
19		√	√		√		√	√			√	√
20	√	√	√	√		√	√	√	√	√		
21		√	√	√			√	√	√	√		
22	√	√	√	√		√	√	√	√	√		
23	√	√	√	√		√	√	√	√	√		
24	√	√	√	√		√	√	√	√	√		
25	√	√	√	√		√	√	√	√	√		
26		√	√	√		√	√	√	√	√		
27	√	√	√	√		√	√	√	√	√		
28									√			
29										√		

Stage 2: The determination of the activity-month preference values

There are many techniques that can be used to determine the preference values or weights for decision-making criteria, ranging from the easier and simpler techniques such as weighted scoring model (Gharaibeh, 2014) and Rank Order Centroid (Ahn, 2011), to the more complicated and detailed techniques such as TOPSIS (Bulgurcu, 2012) and Analytic Hierarchy Process (AHP) (Vaidya & Kumar, 2006). Of all these techniques, arguably, the most used technique is AHP as evidenced by its various applications in project management (Al-Harbi, 2001), operations management (Partovi et al. (1990); Subramaniam & Ramanathan, 2012), location selection problem (Koc & Burhan, 2015), network selection problem (Goyal et al (2018), project proposal evaluation (Kim, 2018), and many others.

Introduced by Thomas L. Saaty (Saaty, 1999), AHP is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. It involves building a hierarchy (ranking) of decision elements and then making comparisons between each possible pair in the form of a pairwise comparison matrix. This gives a weighting for each element within a cluster through the calculation of the matrix's eigenvalue and eigenvector.

To make pairwise comparisons between elements *i* and *j*, a scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property and also with respect to which they are compared will be needed. In this case, the scale is as given in Table 3 (Saaty, 2008).

Table 3: AHP's pairwise comparison scale

Intensity of Importance	Description
1	Two elements, *i* and *j* contribute equally to achieve the objective or goal
3	*i* is slightly favored over *j*
5	*i* is strongly favored over *j*
7	*i* is very strongly favored over *j*
9	*i* is extremely favored over *j*
2, 4, 6, 8	Used to compromise between two adjacent rating above
If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*.	

Associated with the pairwise comparison matrix is an inconsistency measurement. The consistency of pairwise comparison is measured by consistency index (CI) = (λ_{max} –

n)/(*n*-1), where $\lambda_{\max}$ is the largest eigenvalue obtained from the pairwise comparison matrix and *n* is the total number of elements being compared. Meanwhile, the consistency ratio (*CR*) is obtained by forming the ratio *CI*/*RI*, where *RI* represents the random consistency index, can be identified through Table 4. It is recommended that *CR* should be less than or equal to 0.10 (Saaty, 1987) for the pairwise comparison matrix to be considered as consistent.

Table 4: Random index for consistency test

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Despite its many applications as listed earlier, AHP comes with a flaw, which is the difficulty to get respondents to produce a consistent pairwise comparison matrix, especially when the number of criteria is large (Ho, 2008). To eliminate this consistency issue, Nazri et al (2016) proposed a pre-evaluation of the criteria before the pairwise matrix is constructed which according to them would ensure that the pairwise comparison matrix will always be consistent. Specifically, Nazri et al. (2016)'s approach, referred to as C-AHP is as follows:

Suppose we have *N* criteria. Each evaluator must then rate the level of importance of each criterion in determining the weight of that criterion towards the final goal using a scale of 1 to represent least important to 9 to represent extremely important. Suppose also that the evaluator rates criterion *i* as w_i and criterion *j* as w_j. Then c_{ij} which is the pairwise comparison value between criterion *i* and criterion *j* in the Saaty's pairwise comparison matrix *C*, will be determined as follows:

Let $b = w_i - w_j$.

$$\begin{aligned} &\text{If } b > 0 \text{ then } c_{ij} = b+1; \\ &\text{If } b = 0 \text{ then } c_{ij} = 1; \\ &\text{If } b < 0 \text{ then } c_{ij} = 1/(1-b). \end{aligned} \tag{1}$$

Once the pairwise matrix *C* is obtained, the weight for each criterion will be calculated using the existing Saaty's AHP technique.

To illustrate the C-AHP process, we used the evaluation done by the student welfare and entrepreneurial affairs' working committee on activity 19. For the evaluation exercise, instead of asking each member in the team to evaluate individually, they were asked to do the evaluation based on the group consensus. Their evaluation on the activity-month preference is as shown in Table 5.

Table 5: The level of activity-month preference for activity 19

Month	**Preference Level (1 = least preferred, 9 = most preferred)**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Oct'18						X			
Nov'18							X		
Jan'19								X	
Mac'19						X			

Apr’19							X		
July’19									X
Aug’19		X							

Next, applying formula (1), the evaluation was transformed into Saaty’s pairwise comparison matrix, C19 where

$$C19 = \begin{bmatrix} 1 & 1/2 & 1/3 & 1 & 1/2 & 1/4 & 5 \\ 2 & 1 & 1/2 & 2 & 1 & 1/3 & 6 \\ 3 & 2 & 1 & 3 & 2 & 1/2 & 7 \\ 1 & 1/2 & 1/3 & 1 & 1/2 & 1/4 & 5 \\ 2 & 1 & 1/2 & 2 & 1 & 1/3 & 6 \\ 4 & 3 & 2 & 4 & 3 & 1 & 8 \\ 1/5 & 1/6 & 1/7 & 1/5 & 1/6 & 1/8 & 1 \end{bmatrix}$$

Next, the eigenvalue and eigenvector to determine the activity-month preference weight were calculated with the help of an AHP-software, *Expert Choice*. The result is as given in Table 6.

Table 6: The month preference weight for activity 19

Month	**Oct’18**	**Nov’18**	**Jan’19**	**Mac’19**	**Apr’19**	**Jul’19**	**Aug'19**
Weight	0.079	0.132	0.218	0.079	0.132	0.334	0.024
CR = 0.02							

The process was repeated for all the remaining activities, evaluated by the respective working committee group. The results of the evaluation for the entire group are given in Table 7.

Table 7: The activity-month preference weights for all the activities

Act. No.	**2018**				**2019**							
	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mac**	**Apr**	**May**	**June**	**July**	**Aug**
1	032	327	144		-	-	031	327	138	-	-	-
2	-	167	167	167	-	-	167	167	167	-	-	-
3	-	250	250	-	-	-	250	250	-	-	-	-
4	-	228	228	023	-	-	043	228	228	023	-	-
5	-	217	217	033	-	-	068	217	217	033	-	-
6	-	061	061	024	234	378	061	074	024	023	061	-
7	-	049	172	049	-	-	032	078	449	172	-	-
8	-	282	148	023	023	282	050	148	023	023	-	-
9	-	242	242	-	-	-	242	242	030	-	-	-
10	054	114	230	054	-	054	230	230	017	017	-	-
11	-	-	-	-	333	-	-	-	-	-	333	333
12	-	144	326	035	-	-	144	326	025	-	-	-
13	318	128	027	027	-	-	318	128	027	027	-	-
14	-	088	260	022	-	-	088	260	260	022	-	-
15	-	364	091	-	-	-	364	091	091	-	-	-
16	138	138	138	138	-	138	138	138	015	015	-	-
17	-	032	290	032	-	-	032	290	290	032	-	-
18	-	032	290	032	-	-	032	290	290	032	-	-
19	-	079	132	-	218	-	079	132	-	-	334	024
20	025	060	266	040	-	025	266	266	025	025	-	-
21	-	230	230	035	-	-	230	230	024	024	-	-
22	252	152	152	017	-	170	106	106	030	017	-	-
23	150	150	150	036	-	154	154	154	038	014	-	-
24	025	060	266	040	-	025	266	266	025	025	-	-
25	111	111	111	111	-	111	111	111	111	111	-	-
26	-	037	037	191	-	037	037	037	261	362	-	-
27	054	114	230	054	-	054	230	230	017	017	-	-

28	-	-	-	-	-	-	-	-	1000	-	-	-
29	-	-	-	-	-	-	-	-	-	1000	-	-

Stage 3: The 0-1 Integer Programming Model Development

The 0-1 integer programming (0-1 IP) model has been used quite extensively for various scheduling problems such as for university or college course scheduling (Baku & Aksop, 2008; Altunay & Eren, 2016)), vehicle scheduling (Foster & Ryan, 1976), shift scheduling (Cote et al (2011), nurse scheduling (Burke et al (2004), and machine scheduling (Guinet, 1995). A standard 0-1 model is as given by (2).

Maximize or Minimize $\sum_{j=1}^{n} c_j x_j$

Subject to $\sum_{j=1}^{n} a_{ij} x_j = b_i$

for $i = 1, 2, \ldots, m$ (2)

$x_j = 0$ or 1 for $j = 1, 2, \ldots, n$

As mentioned earlier, two scheduling models were developed. Model A was developed based only on the suitability of the activity-month mapping while Model B was based on both the suitability of the activity-month mapping and the working committee's activity-month mapping-preference weights.

For both models, the decision variables were defined as

$$x_{ij} = \begin{cases} 1 \ if \ activity \ 1 \ is \ scheduled \ to \ be \ organized \ in \ month \ j \\ 0 \ otherwise \end{cases}$$

where $i = 1, 2, 3, \ldots, 29$, and j = September 2018, October 2018, November 2018, August 2019.

The two models had the same set of constraints. The constraints were:

i. Each activity must be executed only once, in any of the suitable months, as stated in Table 2.
ii. The total activities to be executed in each month, except for December 2018 and June 2019, should not exceed four activities.
iii. The total activities to be executed in the months of December 2018 and June 2019 should not exceed two activities since the final examination week normally starts in late December and late June.

Having identified all the constraints, the two 0-1 IP model to schedule the activities were developed and are as follows.

Objective function for Model A: To maximize total activities = $X_{1Sep18} + X_{1Oct18} + X_{1Nov18} + X_{1Mac19} + \ldots + X_{2Oct18} + X_{2Nov18} + \ldots + X_{27May19} + X_{27Jun19} + \ldots + X_{28May19} + X_{29Jun19}$.

Objective function for Model B: To maximize total preference score = $0.320x_{1sep18} + 0.327x_{1oct18} + 0.144x_{1nov18} + 0.310x_{1mac19} + \ldots + 0.167x_{2oct18} + 0.167x_{2nov18} + \ldots + 0.170x_{27may19} + 0.170x_{27jun19} + \ldots + x_{28may19} + x_{29jun19}$.

Both models, as stated earlier, were subjected to the same set of constraints as follows.

A. Each activity must be executed only once.

Activity 1: $x_{1sept18} + x_{1oct18} + x_{1nov18} + x_{1mac19} + x_{1apr19} + x_{1may19} = 1$

Activity 2: $x_{2oct18} + x_{2nov18} + x_{2dec19} + x_{2mac19} + x_{2apr19} + x_{2may19} = 1$

…

…

Activity 27: $x_{27sept18} + x_{27oct18} + x_{27nov18} + x_{27dec18} + x_{27feb19} + x_{27mac19} + x_{27apr19} + x_{27may19} + x_{27jun19} = 1$

Activity 28: $x_{28may19} = 1$

Activity 29: $x_{29jun19} = 1$

B. Total activities for all the months except for December 2018 and June 2019 should not exceed four (4) activities. Total activities to be executed in the months of December 2018 and June 2019 should not exceed two activities.

September 2018: $x_{1sept18} + x_{10sept18} + x_{13sept18} + x_{16sept18} + x_{20sept18} + x_{22sept18} + x_{23sept18} + x_{24sept18} + x25sept18x27sept18 <= 4$

October 2018: $x_{1oct18} + x_{2oct18} + x_{3oct18} + x_{4oct18} + x_{5oct18} + x_{6oct18} + x_{7oct18} + x_{8oct18} + x_{9oct18} + x_{10oct18} + x_{2oct18} + x_{3oct18} + x_{1oct18} + x_{12oct18} + x_{13oct18} + x_{14oct18} + x_{2oct18} + x_{15oct18} + x_{16oct18} + x_{17oct18} + x_{18oct18} + x_{19oct18} + x_{20oct18} + x_{21oct18} + x_{22oct18} + x_{23oct18} + x_{24oct18} + x_{25oct18} + x_{26oct18} + x_{27oct18} + <= 4$

…

…

June 2019: $x_{4jun19} + x_{5jun19} + x_{6jun19} + x_{7jun19} + x_{8jun19} + x_{10jun19} + x_{13jun19} + x_{14jun19} + x_{16jun19} + x_{17jun19} + x_{18jun19} + x_{20jun19} + x_{21jun19} + x_{20jun19} + x_{21jun19} + x_{22jun19} + x_{23jun19} + x_{24jun19} + x_{25jun19} + x_{26jun19} + x_{27jun19} + x_{29jun19} <= 2$

July 2019: $x_{6jul19} + x_{11jul19} + x_{19jul19} <= 4$

August 2019: $x_{11aug19} + x_{19aug19} <= 4$

The two models can also be viewed as a transportation model (Taylor, 2015) which is a special case of IP model. Thus, we solved the problem using the transportation model structure as done by a few other researchers such as Hlayel and Alia (2012), and Ji et al (2008). This transportation problem can be represented as an unbalanced transportation tableau as shown in Table 8 for the scheduling of activities without month preference, i.e. Model A. For Model B, the values inside the cells (*) were replaced by the month preference weight values.

Table 8: The transportation tableau to schedule the MPP-activities

Activity	Month, Year												Supply
	2018				2019								
	Sept	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mac**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	
1	*1	1	1	0	0	0	1	1	1	0	0	0	**1**
2	0	1	1	1	0	0	1	1	1	0	0	0	**1**
3	0	1	1	0	0	0	1	1	0	0	0	0	**1**
4	0	1	1	1	0	0	1	1	1	1	0	0	**1**
5	0	1	1	1	0	0	1	1	1	1	0	0	**1**
6	0	1	1	1	1	1	1	1	1	1	1	0	**1**
7	0	1	1	1	0	0	1	1	1	1	0	0	**1**
8	0	1	1	1	1	1	1	1	1	1	0	0	**1**
9	0	1	1	0	0	0	1	1	1	0	0	0	**1**
10	1	1	1	1	0	1	1	1	1	1	0	0	**1**
11	0	0	0	0	1	0	0	0	0	0	1	1	**1**
12	0	1	1	1	0	0	1	1	1	0	0	0	**1**
13	1	1	1	1	0	0	1	1	1	1	0	0	**1**
14	0	1	1	1	0	0	1	1	1	1	0	0	**1**
15	0	1	1	0	0	0	1	1	1	0	0	0	**1**
16	1	1	1	1	0	1	1	1	1	1	0	0	**1**
17	0	1	1	1	0	0	1	1	1	1	0	0	**1**
18	0	1	1	1	0	0	1	1	1	1	0	0	**1**
19	0	1	1	0	1	0	1	1	0	0	1	1	**1**
20	1	1	1	1	0	1	1	1	1	1	0	0	**1**
21	0	1	1	1	0	0	1	1	1	1	0	0	**1**
22	1	1	1	1	0	1	1	1	1	1	0	0	**1**
23	1	1	1	1	0	1	1	1	1	1	0	0	**1**
24	1	1	1	1	0	1	1	1	1	1	0	0	**1**
25	1	1	1	1	0	1	1	1	1	1	0	0	**1**
26	0	1	1	1	0	1	1	1	1	1	0	0	**1**
27	1	1	1	1	0	1	1	1	1	1	0	0	**1**
28	0	0	0	0	0	0	0	0	1	0	0	0	**1**
29	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Demand	**4**	**4**	**4**	**2**	**4**	**4**	**4**	**4**	**4**	**2**	**4**	**4**	**4**

Next, the two problems were solved using *QM for Windows*. The optimal solutions obtained for both model A and Model B are given in Table 9 and Table 10 respectively.

Table 9: The result for Model A (Scheduling without month preference)

Year	**2018**				**2019**							
Month	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mac**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Activity	1	3	2	14	6	20	18	27	28	29		
	10	4	7	17	8	22	21					
	13	5	9		11	23	25					
	16	15	12		19	24	26					

Table 10: The result for Model B (Scheduling with month preference)

Year	**2018**				**2019**							
Month	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mac**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Activity	13	1	3	2		6	10	4	7	26	19	11
	22	5	12	16		8	15		14	29		
	25	9	17			23	20		18			
		21	27				24		28			

3. Discussion and Conclusion

In this paper, we showed how C-AHP and 0-1 IP model via the transportation model were utilized to schedule a set of student activities to be run by the UUM's Student Body for the 2018/2019 academic year. The scheduling results show that without the month preference (Model A), the activities scheduled were concentrated towards the earlier months of the academic year. On the other hand, with the month preference, the scheduling for activities (Model B) was better spread across the months. Furthermore, each of the 29 activities was scheduled to be run on the month that the responsible working committee preferred the most.

To improve on the planning, scheduling, and managing of the activities, we propose that for the next cycle of planning, i.e. 2019/2020 academic year, this Student Body's activity schedule should be completed way before the other student clubs and the academics schools plan and schedule their activities. This will ensure that the activities scheduled by the other student clubs and the academic schools will not compete with the activities that will be offered by the Student Body.

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